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Citrus Diseases of Florida and Cuba Compared with Those of California

By HOWARD S. FAWCETT

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CITRUS DISEASES OF FLORIDA AND CUBA COMPARED WITH THOSE OF CALIFORNIA.*

By Howard S. Fawcett.

INTRODUCTION.

During the months of January and February, 1914, the writer made a trip to Florida and Cuba, for the purpose of collecting bud wood of as many varieties and strains of citrus trees as possible, and to collect information in regard to citrus conditions, especially in regard to citrus diseases. Although much had been written in regard to citrus diseases by workers in California, Florida, and Cuba, some uncertainty still existed as to the identity of some of the important diseases in these places. In some cases, different names were apparently being used for what was thought to be the same disease, and in other cases, the same name was being employed for what appeared to be entirely different diseases. It also seemed that certain important diseases of one state were either absent or of minor importance in the others. This resulted in some cases in unnecessary uneasiness and confusion to citrus growers, especially in cases where articles or bulletins written expressly for conditions in one state, were copied by the agricultural papers of the others.

So far as known, no one acquainted with citrus disease conditions in both Florida and California, had ever made a careful comparative study of them. It, therefore, seemed advisable that this comparative study be made so as to aid the growers and horticultural officers to know which diseases were different and which were identical, and to enable them to more easily detect at once a new disease, should it by any unsuspected means get into the State. As the writer had been connected with the Florida Agricultural Experiment Station, working on citrus diseases for six years prior to his work in California, it was thought that he was in a position to make this comparative study.

Because of the recent discovery of the causal agents of some of the gum diseases in California, a special study and observation of these were made during the trip. The most interesting result of this special work was that the brown rot fungus, *Pythiacystis citrophthora*, which had been proved to be the causal agent in the most common form of gummosis in California, was isolated from diseased specimens in Florida, in Cuba, and in the Isle of Pines.

In this bulletin a comparison of disease conditions between Florida and California will first be considered, and afterwards the conditions in

*Paper No. 10, Citrus Experiment Station, College of Agriculture, University of California, Riverside, California.

Cuba will be discussed separately in comparison with the first two places.

The writer wishes to acknowledge the aid rendered in connection with this study by P. H. Rolfs, H. E. Stevens, E. W. Berger and J. R. Watson of the Florida Agricultural Experiment Station; by F. S. Earle, Robert Luaces, H. O. Neville, A. Beatley, and H. A. Van Herman of Cuba, and by W. T. Horne of the University of California. The author is also indebted to H. J. Webber and H. J. Quayle for helpful suggestions in regard to certain parts of the manuscript.

CITRUS DISEASES OF FLORIDA AND CALIFORNIA COMPARED

One of the most striking differences in the citrus conditions in the two states, is that as a rule the most important diseases in Florida are either absent or of small importance in California and that the most important diseases in California are absent or of less importance in Florida. This is probably due largely to the influence of differences in soil, climate or other environmental conditions in the two states. In Florida, the principal citrus regions lie between 25 and 30 degrees north latitude, while in California they lie between 32½ and 39½ north latitude, or the same latitude as the territory between Washington, D. C., and Charleston, South Carolina. Florida has a rainfall of 40 to 60 inches mostly during the late spring and summer, while the citrus regions of California have a rainfall of 10 to 25 inches mostly during the late fall and winter.

The most widely distributed and perhaps most serious citrus diseases in Florida (not including the extremely serious and recently introduced citrus canker which is discussed later) are melanose (with its associated disease, stem end rot), exanthema, wither-tip, and foot rot. There are others such as scab, nail-head rust, psorosis, Diplodia gumming, blight, and mottled leaf, which locally or in abnormal seasons may assume as great or even greater importance than some of those first mentioned, but which generally are less serious when the entire state is considered.

In California, a corresponding list of the most important would perhaps be the brown rot gummosis (with its associated disease, brown rot of the fruit), mottled leaf, psorosis (also called California scaly bark), and possibly Armillaria root rot (although the last is only serious locally), with foot rot, wither-tip, exanthema, Botrytis gummosis of lemons, Botrytis and Sclerotinia rot of lemon fruit possibly in the list of those of less importance, except locally or in abnormal seasons. It will be seen that none of the list of first importance in Florida appear in the corresponding list in California. Three of the list of most importance in Florida, exanthema, wither-tip, and foot rot, occur in the list of secondary importance in California, and two, psorosis and

mottled leaf, of the list of most important in California, occur in the list of secondary importance in Florida.

As far as possible, diseases producing somewhat similar effects or found on the same parts of the citrus tree, will be taken up in groups: first the gum diseases or diseases principally of the trunk and larger branches; second, the twig, leaf and fruit diseases other than the rots; and third, the fruit rots. Some of the diseases that are rare or of little importance will be found only in the tabulated list at the end of the bulletin.

GUM DISEASES

Considerable confusion and misunderstanding has arisen in regard to gum diseases of citrus trees both in Florida and California because: first, there are at least seven apparently different and distinct troubles in which gum oozes out from the trunk or larger limbs of citrus trees; and because, second, some of these troubles have come to be known by growers and others under one name in California and under an entirely different name in Florida, the same name in at least one case, scaly bark, having been used unfortunately, for different troubles in the two places; and because, third, some forms of gumming appear to be common in one place, and are rare or not found at all in the other.

PYTHIACYSTIS GUMMOSIS (*Pythiacystis citrophthora*).

The Pythiacystis or brown rot gummosis with its associated rot of fruit due to the same fungus, probably heads the list of fungous diseases of citrus trees in California. In 1913,[1] the writer first proved that the brown rot fungus (*Pythiacystis citrophthora* was the causal agent in the occurrence of this most common form of gum disease in California. Another form of gummosis formerly considered the same as the above, was shown to be due in part to another fungus, *Botrytis cinerea.* These two forms are included in the "Gummosis or Lemon Gum Disease," described by R. E. Smith and O. Butler in Bulletin 218 of the California Agricultural Experiment Station.

The Pythiacystis or brown rot gummosis is characterized, especially on lemon trees, by killing of areas of bark on the trunk through to the wood and by the exudation of large quantities of gum. The infection usually starts at the base or just above the crown roots and works rapidly upward and sidewise on the tree. The bark remains firm (not soft) as it is killed without evidence of fungus, and as the bark dries it shrinks and cracks (Fig. 1a) longitudinally. The progress of the disease appears to be most rapid during the late spring and summer in California and is checked in the fall. The lemon bark is most seriously affected. On the bark of old orange trees the progress of the

[1]Monthly Bulletin, State Commission of Horticulture, Volume II, pages 601 to 617. 1913.

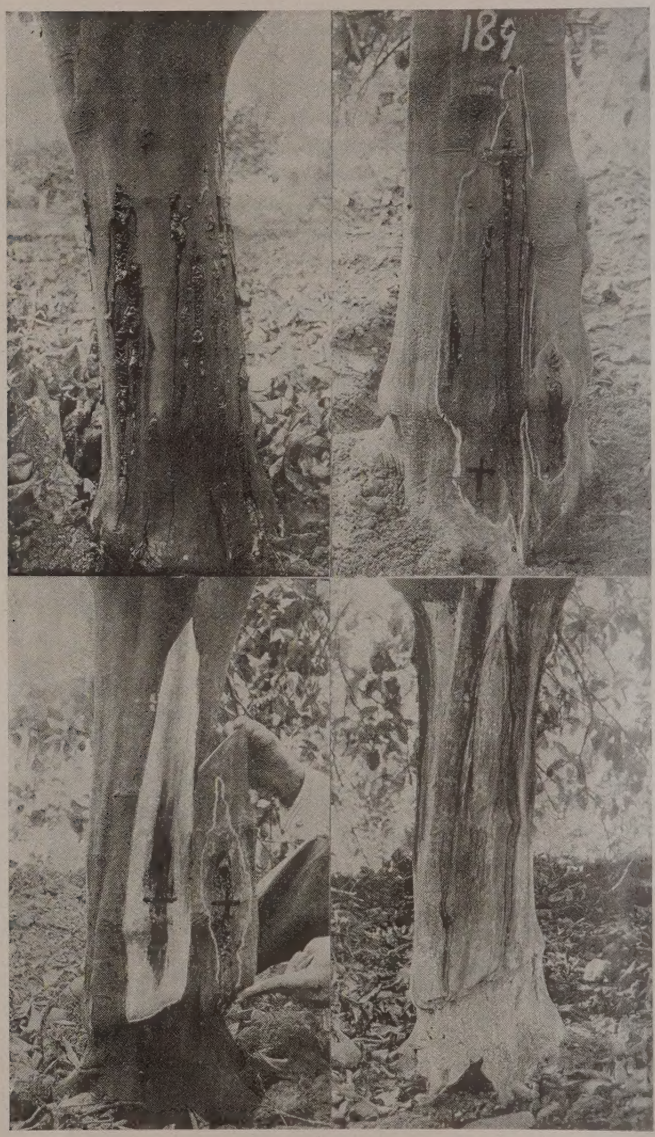

FIG. 1. Pythiacystis or brown rot gummosis on lemon trunks. (*a*) Naturally occurring case on a low budded 15-year-old tree now beyond recovery. (*b*) Tree eighteen years old showing result of inoculation eleven months previous with pure culture of Pythiacystis fungus at X. The white line is drawn around the advancing margin of the killed area of bark. (*c*) Tree eighteen years old with bark cut away to show result of inoculation eight months previous with pure culture of Pythiacystis fungus at X. Bark cut away more than is necessary for treatment. (*d*) Same tree nine months later after being treated with Bordeaux paste showing band of new bark around edges of area cut out.

disease is often soon arrested and the edges of the killed areas heal and the bark breaks away much as in the case of mal di gomma in Florida. This form of gummosis was also found present to some extent in Florida and cultures of *Pythiacystis citrophthora* were obtained from diseased bark of a grapefruit tree that had apparently been affected with mal di gomma or foot rot. The bark was killed entirely through to the wood and the area had progressed upward further than is usual with most typical cases of foot rot in Florida (Fig. 5). The killed bark had the same color and odor as that noticed in connection with the same disease in California.

In Cuba and in the Isle of Pines where the soil is heavier than in Florida, this form of gummosis was seen in nearly every locality visited. The Pythiacystis fungus was obtained in cultures from diseased bark of grapefruit trees at Santiago de las Vegas, Cuba, and from a tangelo tree at Santa Fe, Isle of Pines, but no fruits affected with the fungus were found in Florida, in Cuba, or in the Isle of Pines. The cultures from all of these places, on being placed on lemon fruits in the laboratory, produced typical brown rot identical with that produced by cultures isolated from California specimens of gummosis. As far as the writer is aware, this was the first time that *Pythiacystis citrophthora* has been isolated in cultures from any of these localities. In 1912, Mr. H. J. Ramsey in correspondence with the writer, stated that he had found oranges near Miami, Florida, which, judging from the odor, appeared to be affected with the brown rot as occurring in California, but the fungus was not identified at that time.

The Pythiacystis fungus which lives in the soil usually infects the bark at or below the surface of the soil. The causal conditions for infection are: Improper drainage, continuous, excessive irrigation, letting the water stand too near the trunk, deep planting, or allowing the soil to wash in about the trunks of the trees, and injuries to the bark at the base of the tree in digging about it in wet weather. This applies particularly to heavier soils in California in which the fungus appears to find more congenial conditions for development than in lighter soils. Inoculations have shown that sour orange bark is quite resistant to the attack of the Pythiacystis fungus, while lemon bark is very susceptible, and sweet orange bark stands between sour orange and lemon in its susceptibility. The disease can therefore be largely prevented on lemon trees by budding high on sour orange stocks in order to get the susceptible lemon bark away from the soil. The method of treatment for Pythiacystis gummosis that has been worked out in California by the writer in co-operation with the growers[2] is as follows: The extent to which the bark is killed to the wood in the vicinity of the exuding gum

[2]Fawcett, California State Commission of Horticulture, 2: 601–617, 1913; and Prizer, California State Commission of Horticulture, 4: 7–19, 1915.

is first ascertained by scraping slightly. Then the bark is cut with a heavy knife all around the area about one-half to one inch into the live, unstained bark and a little farther at the top than at the sides, as the fungus usually extends faster upwards than in other directions. Then this entire area of bark that is killed to the wood is dissected out and the wound and the entire trunk is treated with Bordeaux paste. After the area is seen to be healing at the margins of the cut-out area, the exposed wood is then covered with asphalt paint, shellac dressing or other good covering. The formula for Bordeaux paste is: One pound of bluestone (copper sulphate) dissolved in three quarts of water in a wooden, earthen or glass vessel; and two pounds unslaked lime slaked in three quarts of water in a separate vessel of any kind. When the lime is cool, stir the two together, making a slightly pasty light blue mixture.

The possible relation of Pythiacystis to mal di gomma will be briefly discussed later under that subject.

BOTRYTIS GUMMOSIS (*Botrytis cinerea*)*

This differs from the brown rot gummosis in killing the outer part of the bark on lemon trees much in advance of the inner. The writer has never seen it on trees younger than ten years old. An area of bark, usually small, will be found killed through to the wood, but surrounding this a much larger area where the outer bark has been killed and the inner bark is still alive.

The Botrytis gummosis was not found on lemon trees in Florida. The few lemon trees that are left in Florida are usually neglected and are found only as dooryard trees or as chance trees left in an orange or grapefruit grove. Nearly every lemon tree seen was gumming more or less at the trunk, but no Botrytis or Pythiacystis was obtained in cultures from any of these. *Phomopsis citri* or *Diplodia natalensis* appeared to be the most common fungi in the diseased bark. The bark was usually killed through to the wood only in small areas. The form of gummosis was more like a certain scaliness of the bark on old lemon trees in California where the outer bark dies and cracks up in long strips, somewhat like the bark on a shell bark hickory tree of the eastern states. (Fig. 2.) This usually first appears on lemon trees about 15 to 20 years old or older in California. The Eureka variety seems to show it earlier than the Lisbon. It is not yet known certainly whether this is a condition through which old lemon trees naturally pass or whether a fungus which attacks the outer bark may be a causal agent. When the bark is first cracking and loosening, the tree usually appears "out of condition." The old cracked bark tends to encourage gum disease, especially the Botrytis form.

*The specific name of this fungus was tentatively determined by G. E. Atkinson of Cornell University.

In the treatment of Botrytis gummosis, areas that are dead to the wood are cut out as in the Pythiacystis form, but beyond this the outer diseased bark only is scraped off, leaving the inner back attached, and the wound treated with Bordeaux paste or other fungicides that are not injurious to the bark.

FIG. 2. Showing the cracking and scaling (not Psorosis) of bark on old lemon tree trunks in California. Note the freedom from cracking on the orange stock below the bud union.

MAL DI GOMMA OR FOOT ROT.

Foot rot is very common in Florida, especially on old seedling trees. This form of gum disease is scarcely distinguishable from the brown rot gummosis, except that in its most common form in both Florida and California on old seedling orange trees, it scarcely ever extends so far above the ground. Gum exudes on the trunk of the tree above the soil. The inner bark and finally the wood underneath becomes rotten and

often has a very disagreeable, fetid odor. The bark dies and breaks away in patches, leaving bare, dead areas which spread in all directions, mostly down on the main crown roots and laterally around the trunk. (Figs. 3 and 4.) Trees thus affected bear heavily and the leaves become yellow.

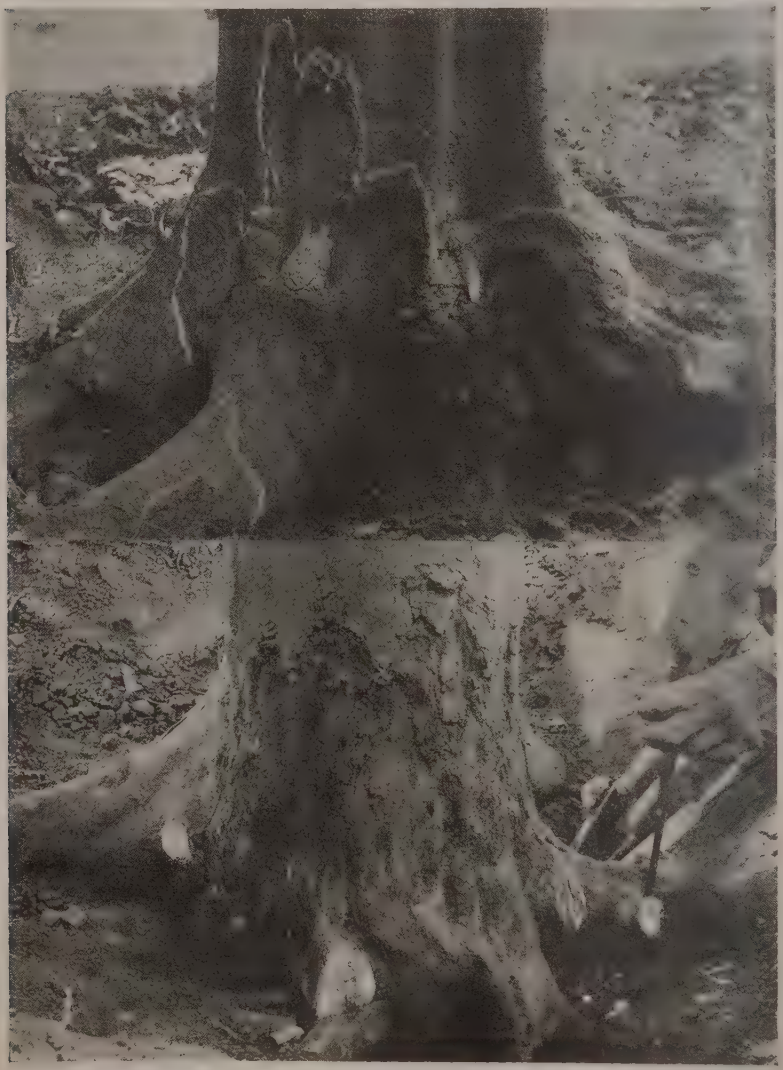

FIG. 3. Mal di gomma or foot rot. (*a*) On forty-year-old seedling orange trees (California). White lines indicate the boundaries of the killed bark. (*b*) Earth dug away and the affected bark and roots being removed before applying Bordeaux paste.

The following conditions appear to favor the development of foot rot in Florida, although cases may be found under all conditions: Improper drainage, too close planting, continuous excessive irrigation, deep planting. These, as will be noticed, are the same conditions as those that favor the occurrence of brown rot gummosis in California. Fortunately, foot rot as well as gummosis may be largely prevented by budding nursery trees to sour orange roots. This has been done for many years in Florida and has controlled the disease perfectly, even in cases in which the sour orange roots were used as resets in badly infested orchards. H. H. Hume[3] says that in order of foot rot resistance differ-

FIG. 4. Mal di gomma or foot rot on sweet seedling orange tree in Florida. (Swingle and Webber.)

ent citrus stocks stand about as follows: (1) sour oranges, (2) pomelo, (3) rough lemon, (4) lemon, (5) sweet orange. The first three, he states, may be roughly classed as decidedly resistant. The last two as much subject to the disease. The writer's observations in Florida and Cuba would lead him to the conclusion that certain strains of pomelo stock were nearly as susceptible to mal di gomma as the sweet orange.

Many foot rot trees have been cured in Florida by digging away the earth, thus exposing and drying out the crown roots, and cutting away and cleaning out the decayed areas and disinfecting them. A number of good disinfectants have been used with about the same success. Some of these are crude carbolic acid and water 1 to 3 parts, Avenarius carbolineum one gallon to one gallon of water in which one pound of whale-

[3]Florida Agricultural Experiment Station Bulletin 53.

oil soap has been dissolved, or Bordeaux paste applied like whitewash (see formula for Bordeaux paste under "Pythiacystis Gummosis"). Cleaning out and drying out the crown roots seem to be more important than the disinfecting.

Sometimes the disease extends farther up on the trunk than usual and in that form appears to be typical with the brown rot gummosis. It would seem from our present knowledge that either there are two diseases that have been going under the name of mal di gomma (foot rot) in Florida or that mal di gomma is only another manifestation of Pythiacystis or brown rot gummosis.[4] (Fig. 5.)

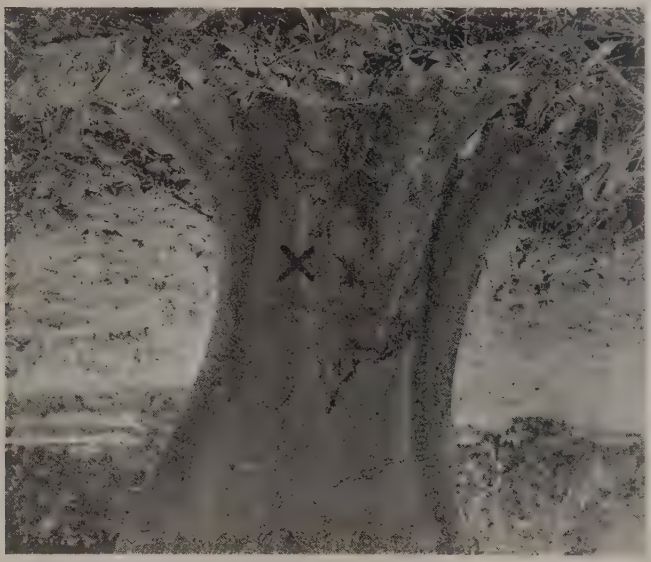

FIG. 5. Mal di gomma on seedling grapefruit tree in Florida. Cultures of *Pythiacystis citrophthora* were obtained from bark taken out at X.

PSOROSIS OR CALIFORNIA SCALY BARK.

The term California scaly bark is used here because of the fact that in Florida the term scaly bark is used for a different disease. The unfortunate use of the same name for two distinct troubles seems to have come about because the names were suggested by a certain scaling and flaking of the bark that is common to the two diseases.

It may be said with certainty that what has been known as Psorosis[5] of orange trees in Florida and what has been known as scaly bark[6] of orange trees in California are one and the same disease. All the symptoms and effects are the same in both places.

[4]Phytopathology 5, 66–67, 1915.
[5]Swingle and Webber, Division of Vegetable Physiology and Pathology, Bulletin 8, p. 30.
[6]Smith and Butler, California Agricultural Experiment Station, Bulletin 200.

The disease is more common and more widely distributed in California than in Florida. In most places in California the Navel orange appears to be slightly more subject to it than the Valencia, and only a few cases of what appears to be the same disease have been seen on grapefruit trees here. The same or a similar trouble is fairly common on grapefruit and tangerine trees in Florida. Only a few trees affected with this disease were seen in Cuba.

FIG. 6. Psorosis on seedling orange trunk in California, showing scales of bark peeling off.

Psorosis manifests itself by the outer bark being broken into scales and pushed up over areas varying in size from an inch to a foot or more in diameter. It begins in a very small area in which simply the outer bark dies, hardens and is pushed off, apparently by the formation of new tissue underneath. This goes on from year to year, sometimes very slowly, only an inch or so each year for several years, before an area of any importance is formed (Fig. 6).

Briefly stated, Psorosis or scaly bark of orange trees may be said to have three stages in its development.

1. The beginning areas, where a small patch of outer bark is cracking up and is being pushed off in scales by the growth of new bark underneath.

2. The enlargement and spread of this first stage, until the areas surround the trunk or limbs without yet killing any wood.

3. A further development of the second stage, until patches of bark are killed through and the wood beneath begins to die for some distance inward. This stage may require from five to ten years' time from the appearance of the first stage.

The first stage may be cured by cutting out affected bark and treating with a good fungicide, such as was mentioned under mal di gomma. The second stage, if on the trunk or largest limbs, may be checked and possibly cured by carefully scraping off dead bark without cutting through the live bark underneath and treating. As far as known to the writer, there is no satisfactory remedy for trees in the third stage. Since the disease is so slow in its progress and its spread, advancing only a few inches each year and often taking five or ten years before doing evident damage, one or two thorough tree-to-tree inspections of an orange grove each year should be sufficient to detect most cases in the first stage, when they are easily cured.

FLORIDA SCALY BARK OR "NAIL-HEAD RUST."

This disease is entirely distinct from the California scaly bark which is treated of under a previous heading. It, as well as the Diplodia gumming, is not known to exist in California. It is also a very destructive disease, because in its severe form it not only covers the tree with ruptured bark from the trunk to the smallest branches and twigs, but also spots the fruits and causes them to drop just before maturity.

It is extremely important, therefore, that neither this disease nor the Diplodia gumming be allowed in any way to get into this State. The disease was fully described and illustrated by the writer in Bulletin No. 106 of the Florida Agricultural Experiment Station. It is known in Florida and distinguished from the California scaly bark by the following characteristics:

1. On the smooth bark of branches 6 to 9 months old and older will be found more or less round or oval spots one-sixth to one-half inch broad, raised above the surface, rusty in color, with well-marked edges (Fig. 7). As the spots grow older the bark becomes glazed, then brittle, shows cracks running lengthwise, and at last breaks into small flakes and scales. In severe cases, these spots increase in number till they join together, forming large patches of rusty or reddish-brown scaly and scabby bark, accompanied by small drops of gum.

2. On the larger limbs, and sometimes on the trunk, will be seen patches of rough scaly bark, the small pieces of which break off as the

hand is passed over them. In this stage it is hard to distinguish it from the psorosis or California scaly bark. (In some cases this scaliness of the old bark may be absent.)

3. On the fruit will usually be found brown sunken spots, some of which are apt to be in the form of sunken rings. These spots are at first yellowish to reddish brown on the green fruit, and finally become dark and sunken. In ringed spots the rings first become sunken with a higher part inside. This central part afterwards sinks in, and the whole area inside the ring becomes dark. The spots vary in breadth from one-fifth to one-half inch.

The initial spots on small branches have been produced by the writer in Florida by inoculation with a fungus known as *Cladosporium herbarum* var. *citricolum*. There seemed to be other unknown factors or

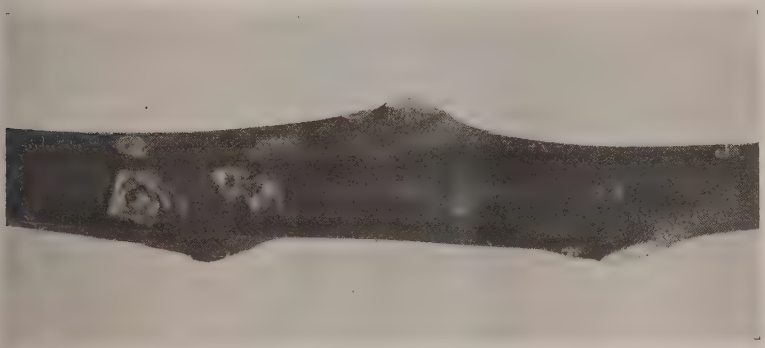

FIG 7. Nail-head rust or Florida scaly bark spots on orange branch about one year old. Natural size. The surface of these spots, unlike those of citrus canker, are hard and glazed and rarely occur on grapefruit.

organisms that entered into the cause for the later stages in the development of the diseased areas.

DIPLODIA GUMMING (*Diplodia natalensis*).

This form of gumming is not known to exist in California. It is fairly common in southern Florida and in Cuba. The writer found a Diplodia fungus present in the discolored bark and wood of limbs affected with this form of gumming. When this fungus was isolated in pure cultures and inserted into cuts in the bark of healthy trees a copious flow of gum with killing of bark and wood tissue always resulted (Fig. 8). The fungus was also found to be capable of causing a rotting of the fruit similar to that described in South Africa. As the fungus appeared from description to be similar to the South African organism, it was considered to be the same species.

This form of gumming is characterized by gum oozing out through cracks in the bark, usually on branches. In severe cases on larger

limbs, areas of bark die and the wood is blackened. The discoloration of the wood often extends along the limbs much beyond any external sign on the bark. When smaller branches are affected they are often killed back to some distance and numerous black spore cases push up through the bark.

This kind of gumming was induced in more than twenty-five different inoculations, covering a period of over one year. That cutting

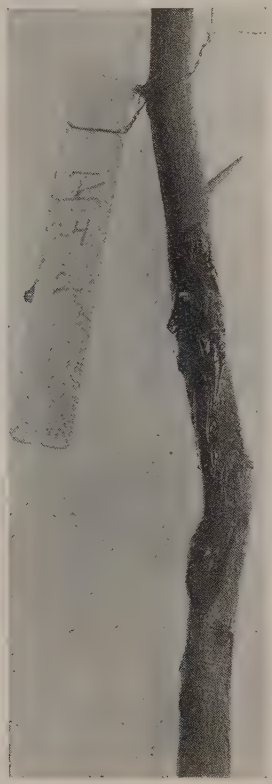

FIG. 8. Diplodia gumming on young orange tree after inoculation with a bit of fungus. (Photo by O. F. Burger and author, Florida Experiment Station.)

into the bark in itself was not the cause of the gumming was proved beyond question, by making with every different set of inoculations the same kind of cuts without the insertion of the fungus. Such cuts protected from contamination always healed up without gumming. The fungus placed on the uncut or uninjured surface of branches or twigs,

however, did not infect them except when the growth was very soft and tender.

Pomelo trees in Florida appeared to be most susceptible to its attack. The fungus probably enters through injuries or wounds. Cutting out the worst diseased limbs, or cutting out the areas as they begin to form on one side of the larger limbs, or cutting out smaller branches entirely, were the methods used in controlling this trouble in Florida.

This fungus, known as *Diplodia natalensis*, was first described in South Africa in 1910 by I. B. Pole Evans in connection with a serious rotting of lemons and other citrus fruits. In Florida, the writer found this fungus to be the cause frequently of a rotting of citrus fruits, especially when slightly injured. It was also found to be the cause of a gumming of peach trees in Florida, by O. F. Burger.[7] The same fungus was found to be capable of killing the bark and inducing gum on a large number of native trees.[8]

ARMILLARIA ROOT ROT (*Armillaria mellea*).

This disease, often known also as oak root fungus and fungus root rot, is not known to occur on citrus trees in Florida or in Cuba, but is troublesome in certain sections of California, especially in localities where affected oaks have been cut down and citrus trees planted. The disease is due to a toadstool fungus *Armillaria mellea*.

More or less gumming often accompanies this disease. It is, therefore, included under the gum diseases. The gum oozes out at or just above the base of citrus trees, and might be confused with that due to foot rot and gummosis. Root rot is characterized by a rotting of the roots out to the ends, and of the bark and wood at the base of the tree, and by the formation of black strands on the roots and of fan-shaped, felted, white growths which crowd into the live bark. It is often accompanied only by a clean mushroom odor and by the development of toadstools of *Armillaria mellea* near the base of the tree in the fall and winter.

The fungus slowly spreads from the roots of an affected tree to the roots of the surrounding healthy trees, often killing a tree in each direction in from one to four years. W. T. Horne,[9] who has investigated this disease in connection with citrus trees in California, states that the treatment of individual orchard trees after they are badly affected is doubtfully worth while, but that trees not girdled by the fungus may be kept alive for many years by digging around the tree, removing all diseased roots and decayed patches of bark and disinfecting the cuts.

In the handling of areas or spots in an orchard where trees are affected or killed out, it is necessary not only to check the outward

[7] Mycologia 3, 151–153, 1911.
[8] Florida Agricultural Experiment Station, Report for 1912, 81–92, 1913.
[9] California State Commission of Horticulture 3, 275–282, 1914.

advance of the fungus so that new trees will not become affected. It is to treat the area already affected before replanting. To prevent new trees from becoming infected, Professor Horne suggests digging ditches so as to inclose the affected areas. This has been effective in preventing infection of new trees for two years, even where the ditches were filled up again. For killing out the fungus in the soil of the affected area before replanting, carbon bisulphid 1½ ounces poured into holes 1½ feet each way and 1½ feet deep has been used by Professor Horne. The use of carbon bisulphid for killing out this fungus was first suggested by C. B. Lipman.

SUMMARY OF GUM DISEASES.

Because of the liability to confusion in regard to these many forms of gum disease, the following brief summary may be helpful:

1. **Brown rot or Pythiacystis gummosis,** characterized by dying of areas of bark clear through to the wood, accompanied by exudation of large quantities of gum, bark remaining firm. Common and destructive in California, especially on heavy soils, found also in Florida and Cuba.

2. **Mal di gomma or foot rot,** probably only a form of Pythiacystis gummosis occurring farther down at the base of trunk and crown roots. Found in Florida, California, and Cuba, especially on old sweet orange seedlings.

3. **Botrytis or grey fungus gummosis,** characterized by dying of a smaller area through to the wood, surrounded by a larger area on which outer bark only is killed. Common only on old lemon trees in coast regions of California. (Not known in Florida or Cuba.)

4. **Psorosis or scaly bark of California.** Found also in Florida, mostly on oranges, the same or similar form sometimes on grapefruit. Characterized by patches of scaly, shaggy bark with gum drops at their edges and with gum-filled outer wood and the formation of new bark under the old, making an ulcerated cankerous appearance on the trunk or larger limbs.

5. **Florida scaly bark, or nail-head rust** (not known in California and Cuba) mostly on sweet orange trees and fruits, characterized by small, rusty, glazed, oval, well-defined spots on the smooth, newer growth, followed by a scaly or scabby surface on the older bark as the branches enlarge, and by reddish brown, hard, sunken spots on immature oranges on the tree, often in the form of rings.

6. **Diplodia gumming,** in Florida and Cuba (not known in California) on all varieties of citrus, characterized by gum oozing out of branches of all sizes, by a killing of the bark, a blackening of the wood and at times by the formation of black spore cases on the bark.

7. **Root rot, or oak root fungus,** in California (not known in Florida or Cuba), characterized by a rotting of the roots, and the bark and wood, at the base of the tree, with black strands or rhizomorphs on the roots and fan-shaped felted white growths crowding into the live bark, accompanied only by a clean mushroom odor (not putrid as in case of the foot rot).

DISEASES OF TWIGS, LEAVES, AND FRUIT EXCEPT ROTS.

CITRUS CANKER (*Pseudomonas citri*).

This new disease, which is attracting serious attention in Florida and the other Gulf States, was first discovered by E. W. Berger,[10] Florida State Inspector of Nursery Stock, who found it on 20,000 young trees in each of two nurseries in Florida in the fall of 1912. At that time it was considered by plant pathologists to be merely an unusual manifestation of scab and therefore its seriousness was not realized. According to E. W. Berger,[11] it was not until July, 1913, that he realized certainly that he had discovered a new disease.

In March, 1914, H. E. Stevens,[12] reported that he had found a species of Phyllosticta fungus which was probably the cause of the disease. In May, 1914, Wolf and Massey,[13] of the Alabama Experiment Station, reported that they had proved by inoculation experiments that a species of Phoma was the cause. Phyllosticta and Phoma being form genera with practically the same characteristics, the fungus obtained in both cases was probably the same. In April, 1915, Clara H. Hasse[14] published an account of finding a species of bacterium, *Pseudomonas citri*, which when grown in pure cultures and placed upon grapefruit leaves, was able to produce citrus canker. The published account of her work appears to leave little doubt that this bacterium is the cause of the disease. A letter from H. E. Stevens, written a few days before Miss Hasse's article came out, shows that he had just discovered that a bacterium and not a fungus was the cause of citrus canker.

The damage from citrus canker is most severe on grapefruit trees, the twigs, leaves and fruit of which are affected. According to E. W. Berger, the different citrus varieties are affected about in the following order: Pomelo, Citrus trifoliata, wild lime, Navel, sweet seedlings, Satsuma, tangerine, King orange and lemon.

Outside of Florida it has been found in Alabama, Mississippi, Louisiana and Texas, and it is known to occur in Japan from which place it is thought to have been brought on nursery stock into this country. The disease has not been found in California. Specimens of the disease, labeled scab, were received by B. F. Floyd at the Florida Experiment

[10] Florida State Horticultural Society Report, April, 1914.
[11] Florida Agricultural Experiment Station Bulletin 124, 1914.
[12] Florida Agricultural Experiment Station Bulletin 122, March, 1914.
[13] Alabama Agricultural Experiment Station Circular 27, 1914.
[14] Journal of Agricultural Research 4: 97, 1915.

Station direct from Japan in May, 1913. Recently it has been reported by the United States Department of Agriculture to be present in the Philippine Islands.

The seriousness of the disease is apparent from following statements in publications on the subject:

"If it is once well established in the State it may become a serious menace to the grapefruit industry" (H. E. Stevens).[12]

"This disease was very severe in certain grapefruit groves during the previous season and threatens to become the most serious difficulty with which the grower will have to contend" (Wolf and Massey).[13]

"This disease is by far the worst which has ever yet affected the citrus industry. The leaves, twigs, and fruit become covered with a cankerous growth. The fruit itself seems to be especially susceptible to the disease, and drops soon after becoming diseased. Canker is so deadly that when the tree first becomes infected, in this territory, it is worthless inside of two or three months" (Stirling).[11]

H. E. Stevens in Bulletin 124 of the Florida Agricultural Experiment Station, gives a good detailed description of the appearance of citrus canker in its various stages as follows:

"The distinguishing feature of citrus canker as observed in the field is the characteristic spotting produced on the fruit and foliage. As usually seen, the infection appears as small light-brown spots, from less than one-sixteenth to one-quarter of an inch in diameter. The spots are usually round, and may occur singly, or several may run together forming an irregular area. This last usually occurs on fruits. The spots project above the surrounding healthy tissue, and are composed of a spongy mass of dead cells, covered by a thin white or grayish membrane. The membrance finally ruptures and turns outward, forming a lacerated or ragged margin around the spot.

"On the leaves, infections first appear as small, watery dots, with raised convex surfaces. These dots are usually of a darker green than the surrounding tissue. Sometimes, however, the surfaces of the spots are broken as soon as they appear. Spots may appear on either surface of the leaf, but they do not at first penetrate through the leaf tissue. They gradually increase in size, change to a light brown in color, and become visible on both sides of the leaf. In the older spots one or both surfaces may be bulged or raised, and such spots are commonly surrounded by a narrow yellowish band or zone. (Fig. 9.) In the more advanced stages, the surface of the spots become white or grayish, and finally ruptures, exposing a light brown spongy central mass. Old spots soon become overgrown by saprophytic fungi, and may appear pink or black on account of these fungus growths.

"On the fruits the spots are very similar to those formed on the leaves. They do not penetrate far into the rind. They may be scattered over the surface, or several may occur together forming an irregular mass. (Fig. 10.) Gumming is sometimes associated with the spots formed on the fruits. Canker, apparently, does not cause a rot of the fruits directly, but opens the way for other fungi to enter and cause

[12]Florida Agricultural Experiment Station Bulletin 122, March, 1914.
[13]Alabama Agricultural Experiment Station Circular 27, 1914.
[14]Journal of Agricultural Research 4: 97, 1915.

FIG. 9. Citrus canker on grapefruit twig and foliage. (Stevens' Bulletin 124, Florida Experiment Station.)

infected fruits to rot. The spots on young twigs are like those on the leaves and fruit. (Fig. 11.) On the older twigs they are more prominent, and more or less irregular in shape. This is especially true of old spots. They show the same spongy tissue that is found in the spots on the leaves, but assume a cankerous appearance and the surface membrance completely disappears. These spots or cankers are formed in the outer layers of the bark tissue, and do not penetrate to or kill the wood. The spots once formed in the bark are presistent, and are not readily sloughed off. They may remain for a long time and form centers from which infections may readily spread. This was confirmed by observations on infections produced on spotted trees in the green-

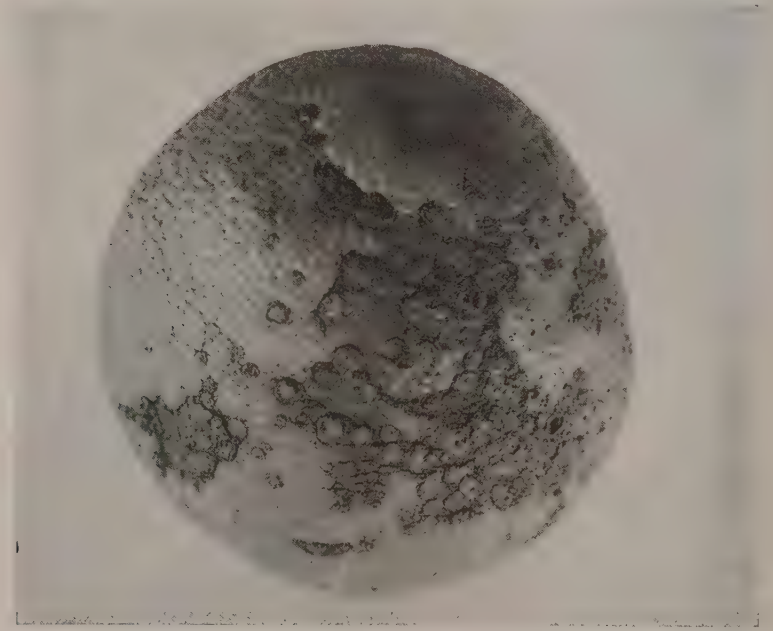

Fig. 10. Citrus canker on grapefruit. About half natural size. (Stevens' Bulletin 122, Florida Experiment Station.)

house, and in the grove by artificial infection. Some of these spots have been under observation for over a year, and show no tendency to slough off.

"Other citrus diseases with which canker may be confused are scab, scaly bark, and possibly Anthracnose. It can, however, readily be distinguished from any of these by noting the following points:

1. It differs from scab in the typically round spots produced; the size of the spots, and the fact that the spots penetrate through the leaf tissue. It does not distort the leaves. There are no wart-like projections. Canker occurs on older wood, scab does not.

2. Canker differs from scaly bark in the size of the spots, which are much smaller and more circular than those of scaly bark and the

spongy nature of the spots—scaly bark spots are hard and glazed. Canker is common on grapefruit, scaly bark is not. Canker forms spots on leaves, scaly bark does not.

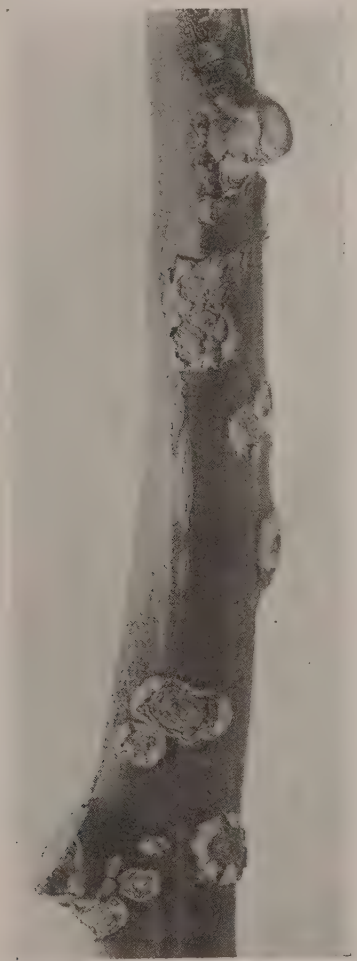

FIG. 11. Citrus canker on *Citrus trifoliata*, showing the light colored membrane around the spots. (Stevens' Bulletin 122, Florida Experiment Station.)

3. Canker differs materially from Anthracnose in the size of the spots, which are much smaller than those of Anthracnose. Canker spots are raised, Anthracnose spots are sunken. Canker has spots of spongy character, those of Anthracnose are hard. Canker occurs on young shoots and older twigs, Anthracnose does not."

Citrus canker appears to be by far the most infectious and destructive disease of citrus trees yet known. It is considered to be so serious that the Florida growers are spending thousands of dollars in an attempt to eradicate it. The growers' organizations in the infected territory have been raising large sums of money, and the Florida Growers and Shippers League has been spending two or three thousand dollars per month. Recently the Federal Government has appropriated $35,000 to assist the Gulf States, $20,000 of which is to be spent in Florida. In a letter from E. W. Berger (February, 1915), he states that the number of inspectors in Dade County, Florida, where the canker is most serious, has been increased from about 40 to 90, and about 175 properties have been found infected in that county up to February, 1915. In April, 1915, the Florida State Legislature passed a crop pest bill carrying an appropriation of $125,000 per year for two years for the eradication of this disease.

The method now being used against the disease is complete destruction of the infected trees by burning. When the control work first began, according to a report by Frank Sterling (Bulletin 124, Florida Experiment Station), the infected trees in groves, and nursery stock were first cut back and defoliated, and the trunks painted with Bordeaux or carbolineum. Two hundred thousand nursery trees and over five hundred acres of grove trees were treated in this way from May to July, 1914. When the trees put out again, however, the new growth was infected as severely as before. This proved to be a complete failure, due, as supposed, to infection from the dead leaves, etc., from the surface of the ground. The method now employed is to destroy by fire every tree showing the least infection. This is done by using a mixture of kerosene and crude oil and applying a torch resembling a plumber's blow torch magnified one hundred times. The tree is burned to the ground and the surface of the soil is thoroughly flamed with the torch. The data so far accumulated since this method has been employed, is reported to show that many groves having only a part of the trees infected have been successfully freed from the disease by burning only the infected trees.

MELANOSE (*Phomopsis citri*).

This disease was first noticed in Florida in 1892 and described by Swingle and Webber[15] in 1896. Later it was studied by B. F. Floyd and H. E. Stevens,[16] of the Florida Experiment Station, the latter having proved it to be due to *Phomopsis citri*, the same fungus that the writer previously proved to be the cause of stem-end rot in Florida.[17] Strange as it may seem, neither Melanose nor stem-end rot have been

[15]Division of Vegetable Physiology and Pathology, Bulletin 8, 1896.
[16]Florida Agricultural Experiment Station, Bulletin 111, 1912.
[17]Florida Agricultural Experiment Station, Bulletin 107, 1911.

found in California. It was of considerable interest to the writer to find also that no Melanose nor stem-end rot could be found certainly in Cuba or on the Isle of Pines (where it has had abundant opportunity for introduction) and that as one passed from northern to southern Florida, Melanose appeared to become less prevalent. At Fort Myers, Florida, only a small amount could be found and at Miami, Florida, only a trace of it in a very mild form. There seemed to be some factors, possibly climatic, causing the disease to be abundant in northern and central Florida and causing it to become less in southern Florida and to be absent in Cuba.

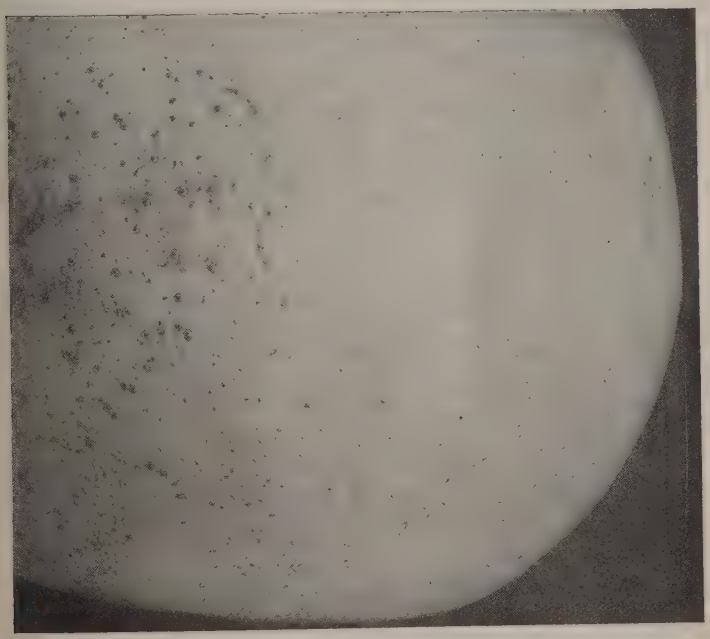

FIG. 12. Melanose spots on grapefruit.

Melanose is a superficial marking of the surface of citrus fruits, leaves and stems. The most noticeable injury is that to the skin of the fruits, causing them to become rough and unsightly, and when severe, stunting their growth. The markings are small, raised areas with a wax-like appearance, varying from yellow to brown and sometimes black. The individual markings or specks (varying in size from mere points to areas one-sixteenth of an inch in diameter) show under the hand lens, lines of breakage around the margins or across the surface, giving the appearance, on a miniature scale, of dry cracked mud, and

when close together gives the surface a flaky appearance. These markings may be distributed irregularly over the surface of the affected parts or, as is often seen, occur in half circles or in lines. (Fig. 12.)

This disease occurs on all varieties of citrus trees in Florida, but is perhaps most noticeable on the grapefruit, because of the smoothness of skin on that fruit. Melanose starts on leaves and shoots only when there is a flush of growth. On the fruit it may start at any time from just after the petals fall until late summer or early fall.

The fungus causing Melanose and stem end rot, lives most naturally in dead branches and even in very small twigs where in moist weather it produces countless numbers of minute spores. These spores are produced in small bodies in the bark that to the unaided eye look like dark specks or minute raised pustules on the surface of the dead bark. The fungus is probably spread in the tree chiefly by dew and rain. The spores are washed down from the dead twigs to the fruit, leaves and new growing twigs. Birds and insects are also no doubt instrumental in carrying the spores from tree to tree. Pruning out dead twigs and branches and spraying are the means used in controlling this disease in Florida.

VERRUCOSIS OR SCAB (*Cladosporium citri*).

Verrucosis, known as scab, is a fungous disease affecting principally the fruit and leaves of sour oranges and lemons and less frequently Satsumas and grapefruit. It occurs as rough, corky projections on the surface of the fruits, causing them to become unsightly and unfit for the market. It attacks the fruit and leaves when young and rapidly growing. (Fig. 13.) Later the tissue becomes immune to attack.

This disease has never been found in California. Before the strict quarantine laws were passed, thousands of sour orange trees with their leaves affected with scab were brought into California, but the new foliage came out free from attack. It would appear that this fungus is unable to persist in a climate like that of California.

The effects of scab are felt most commercially in Florida and Cuba through its attack on grapefruit. While lemons are attacked severely these are not now grown commercially in Florida. (Fig. 14.) It is also severe at times on Satsumas. It was of some interest to note that the scab appeared to increase in its injury to grapefruit as one passed south in Florida and appeared to become even more severe and common in Cuba and the Isle of Pines. The favorable conditions for infection are long continued periods of high atmospheric humidity at the season when the fruit is forming most rapidly. After this critical first growth period is over and the tissue has hardened even a little, the danger from infection is over. Scab is easily controlled in Florida by the use of fungicides and by care in cutting down sources of infection.[18] W. W.

FIG. 13. Scab on sour orange leaves in Florida, taken at Florida Experiment Station. Note the contortions and warpings of the leaves.

Yothers of the Bureau of Entomology, states that the scab was successfully controlled through spraying with commercial lime-sulfur solution, 1 part to 30 parts of water.

WITHER-TIP OF LIMES (*Gloeosporium Limetticolum*).

Wither-tip occurs in its characteristic form on the tender foliage of lime trees. (Fig. 15.) This disease is quite destructive to this variety

FIG. 14. Scab on lemon fruits, Florida. About natural size. (Photograph, W. T. Swingle.)

of citrus trees in southern Florida, especially on the Florida Keys, where many lime trees grow. It is also common in Cuba. This manifestation on the lime was found by Roy E. Clausen to be due to an undescribed species of Glœosporium, which he named and described as *Glœosporium Limetticolum*.[19] Although this fungus is similar in size and shape of spores, and even in manner of spore formation to *Colletotrichum glœosporioides*, which was reported by P. H. Rolfs to be the cause of this and also of other manifestations of wither-tip on other

[18]Florida Agricultural Experiment Station, Bulletin 109, 1912.
[19]Phytopathology 2: 217–234, 1912.

FIG. 15. Wither-tip of lime. 1 to 7 showing leaves and tips of new growth infected with cultures of *Glœosporium Limetticolum* Clausen. 8, 9 *Glœosporium Limetticolum* on agar, dark and white background. 10, 11 *Calletotrichum glœosporioides* on agar, dark and white background. (Clausen in Phytopathology II, 1912.)

varieties of citrus fruits, R. E. Clausen found it to be distinct. The wither-tip of limes has not been found in California.

The method recommended by P. H. Rolfs for the control of this disease is pruning out diseased twigs before the blooming period and then spraying with Bordeaux mixture (Bureau of Plant Industry, Bulletin 52, 1904).

WITHER-TIP OF CITRUS TREES OTHER THAN LIMES (*Colletotrichum gloeosporioides*).

A large amount of wither-tip of oranges, grapefruit and other citrus trees (not limes) in which the newest growth is not withered, but in which there is a slow dying of twigs and branches, occurs throughout Florida and also in Cuba (Fig. 16). This is a rather serious trouble in

FIG. 16. Pruning for a severe case of wither-tip on orange trees in Florida.

many sections in Florida and, as worked out by P. H. Rolfs,[20] is best controlled there by thorough pruning out of all dead and diseased limbs that show any signs of the disease. It is the writer's opinion, based on his observations in both Florida and California, that some of the severest injury in connection with wither-tip of oranges and grapefruit in Florida may be due to the combined effect of *Colletotrichum glœosporioides* and other fungi, such as either *Phomopsis citri* or *Diplodia natalensis,* or both. The last two fungi have not been found in California and this may account for the disease not assuming such severe forms here. Both of these fungi have been shown to be capable of injuring citrus trees when placed in cuts in the branches and they are found abundantly on branches in Florida. In experiments by the writer conducted at the Florida Agricultural Experiment Station in 1911, it was found that these fungi in connection with *Colletotrichum glœosporioides* were apparently capable of doing more damage than when acting alone. The particular strain of *Colletotrichum glœosporioides* used at that time was not able alone to do any appreciable killing of tissue when inserted into cuts, but when combined with either of the other two much injury resulted.[21]

Colletotrichum glœosporioides is widely distributed and abundant in California as well as in Florida. In California it is found associated especially with dead twigs and leaves of trees that have been weakened or subjected to unfavorable soil, cultural, or weather conditions.

In Florida under the moist weather conditions prevailing in the summer much staining of the fruit is produced by the germination of the spores of this fungus, as they wash down from dead twigs above. In California during a season of an abnormal amount of moisture or in localities near the coast, a considerable amount of staining may occur from this fungus, but in drier seasons good specimens of the stain from this source are difficult to find. All varieties of citrus may be stained by this fungus, but the grapefruit is most seriously marked because of its smooth, lighter colored surface. In Florida the tear staining or tear streaking due to the wither-tip fungus is often supplemented by Melanose markings and russeting due to rust mite, so that the fruit is very unsightly unless it has been kept bright by frequent sprayings. The worst stains to fruit in neglected groves in California are usually slight in comparison to the badly stained fruit of similarly neglected groves in some sections of Florida.

The same fungus is also associated both in Florida and California with a spotting of oranges and grapefruit, known as Anthracnose spotting which will be described later under the subject "fruit rots." On very mature fruit it is also connected with serious rotting of fruit in

[20] Bureau of Plant Industry, Bulletin 52, 1904.
[21] Florida Agricultural Experiment Station, Report for 1912, p. 65.

storage or on the way to market. Wither-tip staining of the fruit is prevented by spraying with Bordeaux mixture or ammoniacal solution of copper carbonate.

EXANTHEMA OR DIE-BACK.

This disease is found in both Florida and California, though it is not so common in the latter state. It was not seen at all in the island of Cuba and only a trace of it was found in the Isle of Pines. The investigations upon this disease were begun by Swingle and Webber in Florida and were later carried on by B. F. Floyd, of the Florida Experiment Station. Die-back is thought to be a malnutrition disease.

FIG. 17. Exanthema or die-back markings and splitting on young green oranges. (About natural size.)

Its symptoms are various: gum pockets, dark excrescences and multiple buds on the branches, dying back of branches, and dark irregular markings on the skin of the fruit, with formation of gum at the center of the fruit in the angles of the divisions (Figs. 17 and 18).

Some of the principal causal conditions for Exanthema in Florida are, overfeeding with organic nitrogenous fertilizers, such as stable manure, dried blood and cotton seed meal; hardpan, clay or marl too near the surface; and lack of drainage. When these causal conditions can be corrected, the trees gradually grow out of the trouble. When the disease is caused by overfeeding with organic nitrogen, the mineral form is substituted. It has been found best in Florida to stop as much

FIG. 18. Cross-section of a green orange from a tree affected with exanthema. The darker areas between the septa next to the core indicate the presence of clear gum that has taken the place of the normal tissue. X2.

as possible all cultivation of the soil till the trees have recovered. Dynamiting through the clay or hardpan and improving the drainage conditions when necessary has given good results in the treatment of this disease in Florida. Spraying with Bordeaux mixture both in Florida and California has sometimes been found beneficial against this disease, perhaps because of the stimulating effect of the mixture.

It is of interest to note that in California or in Cuba on the heavier soils the use of organic nitrogen does not seem, as a rule, to bring on Exanthema. In California, however, small local areas of Exanthema in orchards have sometimes been found to correspond with locations of former sheep corrals or cattle barns. In some places in California a

light sandy soil underlaid with gravelly subsoil is subject to Exanthema. On such soils, if a system could be worked out of mulching with straw or vegetation of some kind and of irrigating without the necessity of such frequent cultivation, it would probably be beneficial. With only the general methods now in use, Exanthema, even on light sandy soils in California, appears to be much less common than in Florida on the same type of soils.

MOTTLED LEAF.

This condition of citrus foliage, rather common in some sections of California, is known usually as "frenching" in Florida. The leaves show yellow areas on each side of the midrib between the main lateral veins. (Fig. 19.) A nematode worm (*Tylenchulus semipenetrans*

FIG. 19. Mottled leaf of orange. (Smith Bul. 218, Cal. Exp. Sta.)

Cobb) was discovered by J. R. Hodges, and studied by E. E. Thomas,[22] of the University of California, in connection with the roots of trees affected with this trouble. This nematode worm has been found associated with most cases of this trouble in California, but in only one or two localities in Florida. To what extent it is the cause has not as yet been determined. In Florida, mottled leaf or "frenching" may be seen on

[22]California Agricultural Experiment Station, Circular 85, 1913.

individual trees in a grove or on individual limbs on a tree, but is rarely general throughout any one grove. The stunting of fruit resulting in "small offs," as is sometimes seen in the worst stages of mottled leaf in California, was not seen by the author in Florida or Cuba. Chlorosis in which the leaves turn yellow all over (not mottled) was, however, common in Florida and Cuba.

CHLOROSIS.

Strictly speaking, the word Chlorosis would also include mottled leaf, but it will be used here for a yellowing of leaves rather uniformly over the surface (without mottling). This condition may arise apparently from a lack of nitrogen in the soil or other causes. A great deal of Chlorosis is seen in southern Florida in certain local areas where the soil is underlaid with marl or cochina rock. The trees grow well for a time till their roots strike the marl, when their leaves become yellow, though not necessarily mottled. This condition appears to be corrected on the cochina rock soils, by supplying large quantities of organic matter for the purpose of keeping up the humus. In California also in certain local areas where there is marl near the surface, Chlorosis of this type is seen. There are, however, many other cases of Chlorosis that cannot be accounted for in this way.

CITRUS BLIGHT.

Blight, although not so common as some other diseases, is the most dreaded citrus disease in Florida because nothing is definitely known as to its cause, and because it is likely to attack suddenly the largest and most productive trees in a grove. It has been reported from Cuba, but is not known to occur in California. A large amount of scientific study and investigation has been done upon this disease without so far finding anything that could satisfactorily explain the cause of the trouble. Trees growing on light hammock soils appear to be most susceptible, although it may occur also on other soils. The disease was thoroughly described and illustrated by Swingle and Webber in Bulletin 8 of the Division of Vegetable Physiology and Pathology, in 1896.

The first symptom of blight is usually a wilting of the foliage as if the tree was suffering from drought (Fig. 20). Usually this occurs in early spring and at first appears most pronounced on dry hot days, but later this wilting continues through damp, wet weather. Most frequently a single limb near the top will show signs of wilting after which this condition will spread to the other branches. As the disease progresses, the leaves often drop off, or in some cases the wilting may occur so suddenly that the dry leaves will remain hanging to the twigs. After the top has been injured, numerous water sprouts put out from the trunk and larger limbs. (Fig. 21.) These appear healthy at first and seem to give promise of a new healthy tree only to sicken and die later.

In most cases of blight, the roots appear to be healthy and a great deal of time has been wasted in trying to grow new tops on blighted trees.

Attempts have been made to move the blighted trees to different soil after cutting back the top. For two or three years such trees grow out and give promise of recovery, but later the top sickens and dies back as before. In some respects the disease acts somewhat like peach yellows, the cause of which is not as yet known. As with peach yellows, the

FIG. 20. Branches of adjoining orange trees. (*a*) affected with blight; (*b*) healthy. (Photograph from Swingle and Webber.)

only remedy is the total destruction of the affected trees, so with citrus blight in Florida; the only remedy so far used has been to dig up and destroy a tree as soon as it shows clearly the symptoms of blight.

CITRUS FRUIT ROTS.

In Florida the principal rots and the fungi that take part in each case are: (1) blue mold (*Penicillium italicum*), (2) green mold (*Penicillium digitatum*), (3) stem-end rot (*Phomopsis citri*), (4) Anthracnose (*Colletotrichum gloeosporioides*), (5) diplodia rot, (*Diplodia natalensis*), (6) black rot (*Alternaria citri*).

Of these six species of decay, only four occur in California, namely, blue mold, green mold, Anthracnose and black rot. In addition to these, there are three kinds of decay, principally of lemons, in California which have never been known to cause injury to citrus fruits in Florida; brown rot (*Pythiacystis citrophthora*), cottony rot (*Sclerotinia libertiana*), and grey fungus rot (*Botrytis cinerea*). The brown rot

FIG. 21. Orange tree that has been affected with blight for some time. Suckers from base of tree growing up through it.

fungus has been found, as was before stated, in Florida in connection with gum disease, but it has been reported only once on fruit and that doubtfully, on a few orange fruits at Miami, Florida.

BLUE AND GREEN MOLDS (*Penicillium italicum* and *P. digitatum*).

These molds caused by two closely related fungi are the most common of all rots in both Florida and California. These fungi are apparently unable to enter except through imperfections or injuries to the skin of the fruit. It has been found by many experiments that a large part of this decay may be avoided by careful handling at all stages of picking,

packing and shipping of the fruit.[23] The Florida fruit having, as a rule, a thinner skin and being, as a rule, less firm than the California orange, it is apparently somewhat more subject to injury and decay of this nature than the latter.

STEM-END ROT (*Phomopsis citri*).

Next to the blue and green molds, this decay is the most common and troublesome rot in Florida during certain seasons, when conditions are right for its development. Although fruits sometimes begin to decay at the stem end in California by other causes, the form caused by this fungus is not known to occur in California, nor in Cuba. The writer began an investigation of this disease in Florida in 1909 and found it to be due to an apparently new species of fungus which he described as *Phomopsis citri*.[24] Later H. E. Stevens found that melanose was due to the same fungus. While melanose is a marking of the surface of the fruit produced by the fungus when the fruit is in an immature, rapidly growing condition, stem-end rot is a decay mostly of the interior of the fruit just before or after it is mature. The injury to the fruit is two-fold: first, it causes the fruit to drop and rot just before or after its maturity on the tree; and secondly, it causes a softening and rotting of the fruit in transit, or soon after arrival at the market. This disease may occur on all varieties of citrus fruits.

In the grove in Florida, stem-end rot first appears in August or September on immature oranges or grapefruit as a dark brown, reddish-brown, or black discoloration about the base of the fruit. More often than not, the fruits drop off before any discoloration begins. When the disease attacks the mature fruit, a circular patch at the base becomes soft without discoloration. As the softened area enlarges, covering one-third to one-half of the surface of the fruit, the yellow or orange color of the rind changes through dull brown to dark coffee color. On opening the fruit the decay will be found to have proceeded most rapidly along the fibrous core in the center and along the white inner part of the peel. This rotting may cause much destruction of packed fruit while in transit and after arrival on the market. Shipping tests of carefully picked and packed fruit showed an amount of stem-end rot from zero up to 10 per cent immediately on arrival at Washington; 0.6 to 30 per cent one week after arrival, 8 to 52 per cent two weeks after, and 18 to 68 per cent three weeks after.[25]

The fungus causing stem-end rot is capable of attacking the fruit at the stem even when there is no injury, although certain conditions, such as the presence of scale insects, humidity, heat and lack of vigor of the tree, appear to be predisposing factors in bringing on this decay. Since

[23] Powell, J. H., Bureau of Plant Industry, Bulletin 123.
[24] Phytopathology 2, 109–113, 1912.
[25] Florida Agricultural Experiment Station, Bulletin 107, 1911.

the fungus produces an abundance of spores on the dead branches and limbs, the elimination of these as far as possible is being practiced in Florida for its control.

ANTHRACNOSE (*Colletotrichum glœosporioides*).

This form of decay also known as wither-tip spotting and decay, is especially destructive to grapefruit during some seasons in Florida.[26] It also occurs in Cuba and in California during some seasons. It manifests itself in circular, sunken spots on the rind of the fruit which are at first firm. On very mature or weak fruit the fungus either of itself or by opening up the way for other organisms is able to produce a soft rot, especially in packed fruits on the way to market. The same fungus is associated with it as with wither-tip and tear staining, which have previously been mentioned.[27]

BLACK ROT OF ORANGES (*Alternaria citri*).

This is a disease of oranges that begins at the "blossom" or stylar end. It is not at all common in Florida, but is prevalent in certain parts of California and Arizona, where Navel oranges are grown.[28] It is due to a fungus that enters the navel end of the fruit while it is young. It will sometimes cause young green fruits to exude drops of gum and turn yellowish at the navel end and drop off. The rot is most often noticed just before the normal crop colors. The infected fruits at this time color up sooner than the sound fruits and turn a deep orange color. To outside appearance they look good, but when cut open are found to have a black decayed center. The disease has been observed in Florida on other varieties than the Navel, where it seemed to have begun in a slight defect at the blossom end. The disease does not usually attract enough attention to call for remedial measures. Only a small per cent of the fruit is attacked.[29] In one small grove, however, in northern California, in 1914, fifty per cent of the fruit were reported to be affected with black rot.

DIPLODIA ROT (*Diplodia natalensis*).

This form of decay usually starts at the stem end, as does the stem-end rot, and is similar in appearance at first to the stem-end rot, due to *Phomopsis citri*. It differs by the discoloration becoming darker as the decay proceeds and usually showing dark, wide bands corresponding to the septa or divisions between the segments. It is of minor importance in Florida and has not been found in California. It is most common in Cuba. The writer once received specimens of this decay from Porto Rico. It was first described as causing a serious decay of lemons in South Africa.[30]

[26] Hume, H. H., Florida Agricultural Experiment Station, Bulletin 77, 1904.
[27] Rolfs, P. H., Bureau of Plant Industry, Bulletin 52, 1904.
[28] Arizona Agricultural Experiment Station, Bulletin 58, and California Agricultural Experiment Station, Bulletin 218.
[29] Amundson, California State Commission of Horticulture, **2**, 527–534, 1913.

BROWN ROT (*Pythiacystis citrophthora*).

This form of rot occurs in California and most commonly on lemons. It is not of any economic importance in Florida and Cuba, but has been reported doubtfully as occurring on fruits in one locality in each place. It is a decay of brown color in which the tissue of the fruit remains more firm than in most other rots. When in the open there is no visible growth of fungus on the surface. The fungus develops in the soil and the low hanging fruits on the trees are affected by the splashing of muddy water during rains from the surface of the soil. It is prevented in the orchard by spraying the ground and lower branches with Bordeaux mixture or by covering it with straw in the rainy season, and in the packing-house by using copper sulphate at the rate of 1 pound to 800 gallons in the washing tanks.[31]

COTTONY ROT (*Sclerotinia libertiana*).

Another rot of lemons in California that does not cause any trouble as far as known in Florida or Cuba, is the cottony rot. The fruits are softened and covered with a white mold growth which later forms large irregular black seed-like bodies, the sclerotia. (Fig. 22.) The fungus also sometimes attacks the young shoots of citrus trees, especially lemons, causing the bark to soften and the limbs to gum and die-back.[32].

GREY MOLD (*Botrytis cinerea*).

The grey mold or Botrytis decay begins as a dark discoloration, the fruit then softens and a mouse grey, furry growth of the fungus develops over the surface. This decay is confined principally to lemon fruits in the packing-houses in California. It is not known to affect citrus fruits in Florida or Cuba.

There are in addition to these rots a number of surface spots and markings and pittings of fruit, a few of which will be spoken of here. A more complete list will be found on pages 207–210, at the end of the bulletin.

BLACK PIT (*Pseudomonas citriputeale*).

This is a black sunken spot of citrus fruits in California due to a bacterium. The cause was worked out by C. O. Smith[33] of the Southern California Pathological Laboratory. The organism is thought to gain entrance at slight injuries, such as thorn punctures and the like. It is only a minor trouble. As far as known, it does not occur in Florida or Cuba.

[30]Evans, I. B. P., Transvaal Department of Agricultural Science, Bulletin 4, 1910.
[31]California Agricultural Experiment Station, Bulletin 190, 1907.
[32]Smith, C. O., California Cultivator, 35: 196–197, September 1, 1910.

BROWN SPOT.

A spot disease occurring principally on Navel orange fruits in California is known by this name. The spots vary in size from a mere point to one-fourth inch in diameter; they are dark brown and sunken, begin to develop five to ten days after the fruit is picked, and are usually not visible on the tree. J. E. Coit[34] attributes the spotting to the premature death of certain cells near to surface of the rind due to oxidizing enzymes. The primary cause or agent that brings about this result is as yet unknown.

FIG. 22. Cottony rot on lemon showing mycelium and sclerotia of *Sclerotinia libertiana*. (Smith, Bul. 218.)

PETECA.

This occurs on lemon fruits as a deep pitting, due to the sinking of the surface of the rind after the fruit has been some time in the curing house. Although the surface cells at the bottom of the pits are at first normal, the tissue underneath these in the inner part of the peel are dry and shrunken. This trouble appears to occur only during the fall and

[33] Phytopathology 3, 277–281, 1914.
[34] Proceedings of Society for Horticultural Science for 1910.

winter months in California and disappears on the lemon fruits of other seasons. It is not known to occur in Florida or Cuba, but is said by Ralph E. Smith, to occur in southern Europe. No cause or remedy for this disease is yet known. (Fig. 23.)

GREEN SPOT.

A marking of the surface of lemons known as "green spot" is troublesome during some years in California. It is not known to occur in Florida or Cuba. It usually occurs in the fall and winter on the fruit that has come in green or light green from the orchard. The spots remain green in color after the remainder of the surface of the rind turns yellow in curing. In the spots the oil cells stand out prominently, the surface between them having been slightly depressed. It

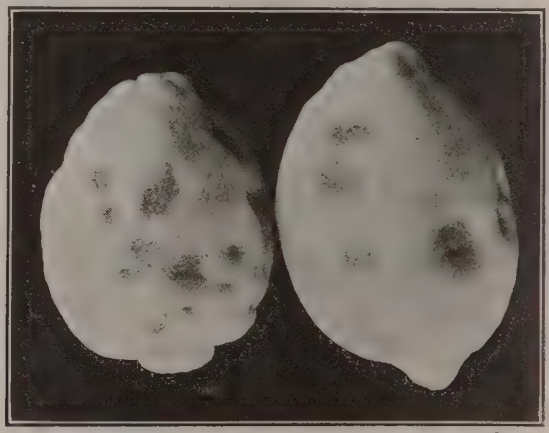

FIG. 23. Peteca of lemons. (Smith, Bul. 218.)

has been found recently that one of the causes for these spots is the effect of lemon oil liberated from some of the cells of the rind in picking and handling. J. D. Culbertson, of the Limoneira Company, first showed by experiments on sound lemons that the oil pressed out of the rind of one fruit had a remarkable effect on the rind of another fruit uninjured. The writer caused the development of the typical "green spot" in moist jars, by pressing out on the uninjured surfaces of green fruits small quantities of lemon oil. The spots were also produced by a pressure of the skin just sufficient to liberate the oil. Fruits not so treated kept under similar conditions developed no green spots. The depression of the surface of the rind between the oil cells took place in a few hours, but the typical green spot was only evident in four to six weeks, after the remainder of the rind had turned yellow.

THE PRINCIPAL INSECT PESTS OF FLORIDA AND CALIFORNIA COMPARED.

WHITE FLIES.

Only the more important insect diseases of citrus trees will be mentioned. In Florida the most serious pest in most sections, is the citrus white fly. In importance, this pest holds in Florida the place that the black scale holds in southern California. There are two species to which the name citrus white fly is usually given, *Aleyrodes citri* and *Aleyrodes nubifera.* There is a third species usually known as the Cuban or woolly white fly, *Aleyrodes howardii,* that is now spreading over all the southern part of Florida in eight counties.

FIG. 24. Citrus white fly parasitized by fungi. (A) Brown fungus (*Ægerita webberi.* (B) Red fungus (*Aschersonia aleyrodis*). Each pustule indicates the position of a white fly larva that has been killed by the fungus. (H. J. Webber.)

The citrus white fly in its adult stage is a gnat-like insect. The eggs are laid upon the under side of the citrus leaves and hatch into flat, scale-like larvæ, which suck the sap from the leaves. The injury to the tree is caused both by the sucking of the sap and by the black sooty mold fungus, *Meliola* sp., that grows in the secretion of honeydew from the white fly larvæ. When there is a bad infestation of this insect, the surface of the leaves, twigs and fruit become coated with a layer of the sooty mold fungus in a manner similar to that following a very bad attack of black scale (*Saissetia oleæ* Bern.) or mealy bugs (*Pseudococcus citri* Risso.) in California. The white fly has three well-defined broods or cycles in Florida. The adults of the first brood hatch and are on the wing during March and April, the second during June and July, and the third during August, September and October.

It is interesting to note the manner in which the white flies are attacked by fungi in Florida. There have been found six different species of fungi that are parasites of the citrus white fly in Florida, namely, *Aschersonia aleyrodis* (Fig. 24A) *Aschersonia flavo-citrina*, *Ægerita webberi* (Fig. 24B), *Microcera* (Fusarium) sp., *Verticillium heterocladum*, and *Sphærostilbe coccophila*. The first four of these are quite efficient in helping to keep the insect in check under favorable conditions of moisture and temperature. The first three attack the larvæ or scale-like stage of the white fly. *Microcera* sp. attacks larvæ and eggs. When the fungi become thoroughly established in a moist locality the grower, without any other aid, usually counts, during average conditions, on at least one clean crop in three years. This is thought to be due to the fact that the fungi have become so abundant one year in three that the insects are nearly all killed. The following year the trees are practically clean because there are very few insects left. The fungi, however, having used up the food supply the year before, have become scarce. The few insects which remain increase rapidly and the next year become numerous enough to smut the fruit somewhat, and the second year so numerous as to smut the fruit badly, but by this time the fungus parasites have again increased to such an extent as to nearly exterminate them again. The third year is therefore again a year with few insects and clean fruit. If conditions are not normal, this three-year period may be changed to a shorter or longer period, depending largely on weather conditions. In some unusually moist situations the fly may be practically controlled by the fungi for several years in succession without other aid. When a dry year occurs the fungi are unable to keep the white flies in check. The fungi do most of their work in the rainy season and the insects multiply most in the dry season or during periods of lack of moisture. If the rainy season, therefore, lasted all the year in Florida, the white fly would probably be sufficiently

controlled by the fungi without any other aid. It would, therefore, seem that if the white fly once became established in the drier climate of California where the parasitic fungi probably would not thrive, it would be a much more serious pest than it now is in Florida. We have one insect, the black scale (*Saissetia oleæ*) occurring in both California and Florida, whose occurrence in the two states indicates something as to what kind of a pest we could expect the white fly to become in the drier climate of California where its fungus parasites would not thrive. The black scale is probably the most serious general insect in southern California, yet in Florida and Cuba, it is not abundant enough to be of any consequence whatever. It is probably controlled largely in those places by both fungus and insect parasites. Even in moister regions of California, as in Santa Barbara County, the black scale appears to be partially held in check by a species of Isaria fungus, assisting the Scutillaria and other parasitic insects.

A method has been in use for some years in Florida of aiding in the distribution of the fungi by spraying the trees with water in which spores of these fungi have been placed. This method was first brought out by Dr. E. W. Berger of the Florida Experiment Station, and at the present time hundreds of acres are being treated in this way. Spraying with oil sprays is also being generally used in controlling this insect. W. W. Yothers, of the Bureau of Entomology, has developed a heavy oil spray, an emulsion of lubricating oil in whale-oil soap, that is now being used against this pest and against scale insects as well. The work of the fungi is often supplemented by spraying at periods when the fungi are unable to keep the insect in check. As regards fumigation with hydrocyanic acid gas, Professor J. R. Watson, Entomologist of the Florida Experiment Station, says: "So far as I know at the present time (November, 1914), there is not a grower in Florida who fumigates regularly." This, to be successful, would have to be done by communities, because of the possibility of the adult fly reinfecting a clean grove by flying over from a neighboring infested one. Not all communities in Florida are yet infested with the citrus white fly, but year by year it is spreading to new places. The wonder is that some places only a few miles separated from others badly infested, have remained free for so many years.

The white fly at one time became established in three widely separated localities in California: Bakersfield, Oroville, and Marysville—but by severe measures, it has apparently been entirely eradicated, except on a few trees at Marysville.

THE PURPLE SCALE (*Lepidosaphes beckii*).

Next to the white fly the purple scale, *Lepidosaphes beckii*, is the most important insect pest in Florida. This insect is widely distributed throughout all the citrus localities of the state and at times becomes very troublesome. This scale is attacked by at least four different fungus parasites, *Microcera* (Fusarium) sp., *Sphærostilbe coccophila, Ophionectria coccicola* and *Myriangium duriæi*, and sometimes by a fifth, *Verticillium heterocladum*. These fungi, together with insect parasites under quite favorable moisture conditions in Florida, keep the purple scale down so that it does little damage to the trees and fruit. During a normal dry season, generally during the winter and spring in Florida, especially in higher localities or in regions exposed to drying winds, the fungi are unable to keep pace with the insects and they become very abundant and injurious. When groves that have never had the white fly in them first become thoroughly infested with this insect, the purple scale at first also increases considerably. J. R. Watson,[35] has recently explained this increase by the fact that the crawlers or young are driven by strong light to seek shelter under the sooty mold or under the calyx of the fruit, etc., and having once taken up their position there, are protected from their enemies, the lady beetles and perhaps also from the fungi. The sooty mold would naturally act as does cotton in preventing the passage of wind-blown spores through it to the insects underneath.

In California the same species known as purple scale is found principally in the coast regions of Santa Barbara, Los Angeles, Orange and San Diego counties, but none of the fungus parasites before mentioned are present here. It is also an important pest in these places. A number of attempts by the author to introduce the red fungus (*Sphærostilbe coccophila*) on purple scale into Santa Barbara and San Diego counties, have failed completely. It is likely that the climatic conditions of California are not suitable for the growth and development of this fungus.

OTHER SCALE INSECTS.

Other insects in Florida which at times are important pests are the long scale (*Lepidosaphes glovcrii*), Florida red scale (*Chrysomphalus aonidum*), chaff scale (*Parlatoria pergandei*), cottony cushion scale (*Icerya purchasi*), and mealy bug (*Pseudococcus citri*). Only the last two of these are found to any extent in California. In California only a small amount of the long scale is present in San Diego County. The "red scale" of California is a different species (*Chrysomphalus aurantii*), and other scales of considerable importance in California in certain localities are the yellow scale known as a variety (var.

[35] Florida Agricultural Experiment Station Bulletin 123, 1914.

citrinus) of the red scale, greedy scale (*Aspidiotus rapax*) and a comparatively new pest, Citricola scale (*Coccus citricola*). In California, fumigation with hydrocyanic acid gas or spraying, and in a few cases insect parasites, are the means used in controlling scale insects. In Florida, fumigation is used scarcely at all and the fungus parasites supplemented by spraying are employed.

Besides these, a number of other insects are mentioned in comparison with those of California and Cuba on pages 203–206 with their known fungus and insect parasites.

RED SPIDERS AND MITES.

There are three species of mites that are troublesome and widely distributed all over Florida, viz: the red spider, *Tetranychus mytilaspidis,* the six-spotted mite, *Tetranychus sexmaculatus,* and the rust mite, *Eriophyes oleivorus.* The red spider is the same pest that is so troublesome in California, the other two are not widely distributed in California and are found only to a limited extent in San Diego County. All these mites are successfully controlled in Florida as in California, by spraying with lime-sulfur, or by using powdered sulfur in hot, damp weather. An interesting observation that has been made by the growers for years in Florida, and which has also been noticed by the author many times, is that the rust mite seems to be much more prevalent on high pine lands than on lower hammock lands, and also appears to be worse on groves that have been clean cultivated than on groves where the weeds or cover crops are allowed to grow throughout the summer. This same difference as to amount of russeted fruit between mulched and unmulched trees was also observed in Cuba. The fruit on the mulched trees were almost invariably freer from attack of rust mite than the fruit on other trees not mulched in the same soil. No satisfactory explanation of this difference is known to the author. It may possibly be due to there being parasites of the mites that keep them down in lower situations and that are not so abundant in cultivated places or in clean cultivated lands.

CITRUS DISEASES IN CUBA AND THE ISLE OF PINES.

INTRODUCTION.

About two weeks were spent in Cuba and the Isle of Pines. As the localities where citrus is grown are scattered from one end of Cuba to the other, there was not time enough to visit more than a few of the localities where citrus fruits were grown. The localities visited were Herradura in the province of Pinar del Rio, Santiago de las Vegas in the province of Havana, Ceballos in the Camaguey province, and Santa Fe, McKinley and Santa Barbara in the Isle of Pines, which were said to be representative localities.

According to statistics published by the *Cuba News* of Havana in 1913 there were nearly 20,000 acres of citrus fruits then growing commercially in Cuba and the Isle of Pines, most of it ranging in age from one year to about ten years. This does not include the older scattered citrus trees throughout the islands. In round numbers, about 14,000 acres of this are grapefruit, 5,000 acres are orange, and 800 acres are lemons. Most attention is being paid to grapefruit for shipping, oranges being grown principally for local consumption, and little attention is now being paid to lemons.

In climatic conditions, Cuba and the Isle of Pines are similar in many respects to southern Florida. The rainy season occurs in summer and the drier period in winter, just as in Florida. Cuba and the Isle of Pines, being between 20 and 23 degrees north latitude, have one great advantage over most of the citrus regions of Florida and California, viz, the total freedom from frost injury. The most tender varieties of citrus and tropical fruits may be raised without danger from such injury.

One very serious injury aside from the insect pests and diseases to citrus growing in Cuba during some seasons, however, is heavy winds, which gain a velocity at times, to the extent of becoming hurricanes. These cause much injury to groves that are exposed. The fruit is whipped about and the trees are severely injured. This injury has in some places been prevented in great measure by the use of suitable windbreaks and much interest is being taken in the planting of windbreaks at the present time.

INSECT PESTS.

BLUE-GREEN BEETLES.

Perhaps one of the most serious pests in the islands are the blue-green beetles, *Pachnæus litus* and *P. azurescens*, that eat out small patches of the rind of the young fruits and cause them to become misshapen. The larvæ of these beetles live in the soil and eat the bark from roots of

the trees. The beetles usually begin to appear at the time of the early rains in April and May and continue in decreasing numbers until October. The injury from the larvæ on the roots is said to show most in the dry season in winter and early spring. The trees turn yellow and in severe cases die. No satisfactory practical method appeared to have been used to any extent for controlling these beetles in large trees. For small trees, shaking the beetles off upon a sheet stretched under the tree and killing them, had been tried with fair success.

LEAF-CUTTING ANT.

Another pest of constant annoyance is the leaf-cutting ant known as the "bibijaga," *Atta insularis.* A colony of these ants in one night may completely defoliate a number of citrus trees. The ants use the leaves in making a pulp or culture medium for a certain species of fungus which they cultivate with great care for their food in underground nests. The nests are usually located in the woods or uncultivated lands and the ants travel sometimes great distances to certain trees which they choose to defoliate, carrying the pieces of leaves raised over their heads. The ants look after this special fungus with great care and are said to weed out all contaminating fungi or molds and to nip off the vegetative hyphæ so as to cause the fungus to produce the particular growth which they use for food. These ants were very annoying and would sometimes completely defoliate several trees before their presence would be detected. The most common means of combating them appeared to be the use of carbon bisulphid, poured into their nests.

WHITE FLIES.

Of the three serious citrus white flies spoken of as occurring in Florida, only the woolly or Cuban white fly, *Aleyrodes howardii,* is of any importance in Cuba and it is not considered a very serious pest. A few specimens of what appeared to be the cloudy wing white fly, *Aleyrodes nubifera,* were seen near the Cuban Experiment Station, where it was not abundant enough to be considered a pest. The woolly species was seen in several localities, but was not serious. Both these species appeared to be kept well in check by some natural enemies, perhaps by both fungus and insect parasites. A fungus parasite, *Aschersonia aleyrodes,* has been found on both these species in Cuba.

SCALE INSECTS AND MITES.

A number of different scale insects exist on citrus trees in Cuba, but their injury is lessened on well-cared-for trees in moist localities because of the prevalence of a number of fungi that are parasitic upon them. As in Florida, the most widely distributed scale insect appeared to be the purple scale, *Lepidosaphes beckii.* It is attacked also as in Florida by the white, red and black fungi, known scientifically as *Ophionectria coccicola, Sphærostilbe coccophila,* and *Myriangium duriæi.*

Next to the purple scale, perhaps the small white Chionapsis scale (*Chionaspsis citri*) was the most important. It is common especially on the limbs of old neglected citrus trees and although attacked by some of the parasitic fungi, is not so fully kept in check as some others. *Myriangium duriæi* and *Sphærostilbe coccophila* were found attacking it.

Perhaps the third scale insect in importance was the large turtle back scale, *Lecanium* sp. W. T. Horne in a letter says of it: "It is doubtless one of the three worst orange scales in Cuba. It is very bad, has a vile odor and goes down on the roots. It is also on avocado. It is bad in dry seasons, but checked by its enemies in wet seasons."

The other scale insects more or less common were *Chrysomphalus aonidum, Lepidosaphes gloverii, Parlatoria pergandei, Coccus hesperidum, Ceroplastes floridensis.*

Mealy bugs, red spiders and rust mites appeared to be nearly the same in importance as in Florida. For a more complete description of insect pests of Cuba, see Bulletin 9, of the Cuban Experiment Station, by Cook and Horne.

DISEASES OTHER THAN INSECT PESTS IN CUBA.

Since many of the diseases have been discussed at some length in connection with Florida conditions, they will be little more than mentioned in this discussion of Cuban diseases. Of diseases other than insects perhaps the various forms of gum diseases were the most important. The different forms of gum disease were practically the same as those of Florida, except that Florida scaly bark or nail-head rust was not found there.

GUM DISEASES.

Mal di gomma or "foot rot," as it typically occurs in Florida on old seedling orange trees, and a few cases of **Psorosis** (California scaly bark) were seen. **Diplodia gumming,** due to *Diplodia natalensis,* in which fair sized branches were killed back was probably the most common of the gum diseases. It was seen in nearly every locality visited. This may possibly be the disease spoken of under "twig gummosis" by W. T. Horne, in Bulletin 9 of the Cuban Experiment Station. Grapefruit (pomelo) trees seemed especially susceptible to this trouble. The same fungus was also found in nearly every locality in decaying pomelo fruits. A gum disease on the trunks of lemon trees was also fairly common, but it appeared to take a different form from either the Pythiacystis or Botrytis gummosis in California or foot rot in Florida. There appeared to be a large amount of exudation of gum with a small amount of killing of bark. The outer bark was killed ahead of the inner, somewhat like the Botrytis form, but the Botrytis fungus was not found in it.

The most serious form of gum disease in Cuba, common on heavy soils, appeared to be the **Pythiacystis gummosis.** Beginning at the base of the trunk the bark was killed for some distance above the ground with the exudation of considerable gum. This form in most cases resembled closely the Pythiacystis (brown rot) gummosis, as it occurs in California on heavy soils. It is strongly suspected that this may be only one form of mal di gomma (see previous discussion under California and Florida). The bark was killed rapidly clear through to the wood and had the characteristic odor of bark killed by Pythiacystis. From specimens of such bark from a grapefruit grove at Santiago de las Vegas, cultures of *Pythiacystis citrophthora* were obtained. As a culture of Pythiacystis was also obtained from similar specimens on the Isle of Pines and also at Palmetto, Florida, it would seem that this fungus is the causal agent in that particular type of gummosis there as well as in California.

Scab (Verrucosis) *Cladosporium citri.* Probably next in importance to the gum diseases, was scab, especially on grapefruit. During years when the moisture and growth conditions are favorable for infection by the scab fungus, a great deal of trouble is experienced from this disease. It attacks the young fruits, just as they are growing most rapidly. The off bloom or "June bloom" fruit is most apt to be infected seriously. The leaves also may be contorted and warped out of shape by it. The copper sprays (Bordeaux and ammoniacal copper carbonate) have been used successfully in preventing it, but the increase of scale insects due to killing off of the fungus parasites of the insects is so rapid that many growers hesitate to spray with these copper fungicides. Lime sulfur is being tried out and is reported to have given good results.

Wither-tip of Limes (*Glœosporium Lemitticolum.* Wither-tip of lime trees, the same as occurs in south Florida, appeared to be a prevalent and serious disease throughout the island. It blights the new growth as it comes out and interferes materially with the setting of young lime fruits. This is the disease which Mr. Roy Clausen of the University of California, determined to be due to a fungus resembling but apparently quite distinct from the *Colletotrichum glœosporioides,* which is associated with wither-tip of other varieties of citrus in both Florida and California.

Blossom End Rot of Persian Limes. Wherever the Persian limes were found, there was a certain amount of a firm rot at the "blossom" or stylar end of the fruits. This appears to be the same as has been observed in Florida and in one case in California. It appears first as a whitish, sunken patch around the stylar end. This patch remains firm and does not, as a rule, soften much as in some other kinds of decay. The cause is as yet unknown. It would appear to be due to an

organism of some kind. A fungus resembling *Colletotrichum glœosporioides* was found commonly in the spots, but was not determined to be the cause of the trouble.

Diplodia Rot (*Diplodia natalensis*). A decay especially of grapefruit which begins at the stem end and slowly rots the fruit, was quite common. (The "stem-end rot," due to *Phomopsis citri* was not seen). Cultures made from such fruits at various localities showed the Diplodia fungus to be present. This aside from the blue molds appeared to be the most important decay. The same fungus has already been mentioned in connection with the Diplodia gumming on branches. In some places considerable tear streaking, probably due to the wither-tip fungus, was also seen.

Leaf Spot, due to an Alga (*Mycoidea parasitica*). A certain amount of damage appears to be due to a species of alga attacking the leaves, producing a wart-like growth. This is not known to be present on citrus in either Florida or California. The damage from any one spot is negligible, but when the leaves become covered with spots they are weakened and fall off. It has not usually been considered serious enough to use any methods of prevention in Cuba. Any fungicide would probably prevent it.[36]

Dark Greasy Spot ("Black Melanose"). Although the true Melanose appeared to be absent in Cuba and the Isle of Pines, a dark, greasy spot sometimes called in Florida "Black Melanose," was very common, especially on grapefruit leaves. The writer's observations would lead him to say that this dark, greasy spot increases in prevalence and effect, as one passes from the northern to the southern part of Florida and is even more prevalent in Cuba and the Isle of Pines. The spots have a dark, slightly raised, greasy appearance, suggestive of a mass of dark grease under a transparent epidermis. Their development on leaves in Cuba is much more definite than in most parts of Florida and would strongly suggest the effect of some organism. This would be suspected even more strongly since the discovery by H. E. Stevens in Florida, that the true Melanose is due to *Phomopsis citri*, the same fungus as causes stem-end rot.

[36]Cook and Horne. Cuban Agri. Exp. Sta. Bul. 9.

A TABLE COMPARING CITRUS INSECT PESTS OF CALIFORNIA, FLORIDA A&D CUBA.†

4 Important. 3 Important only at times or in few localities. 2 Not important. 1 Trace of it reported. 0 Not known to occur.

Common and scientific name	Occurrence			Insect parasites	Fungous parasites	Treatment indicated
	California	Florida	Cuba			
Clear-winged white fly *Dialeurodes citri* (*Aleyrodes citri*)	1	4	1	Several lady beetles, but of little importance. 1	*Aschersonia aleyrodis* 4 *Aschersonia flavo-citrina* 3 *Ægerita webberi* 4 *Microcera* (Fusarium) *sp.* 4 *Verticillium heterocladum* 3 *Sphærostilbe coccophila* 1	Use of fungi, spraying with oil emulsions or fumigation.
Cloudy-winged white fly *Dialuerodes citrifolii* (*Aleyrodes nubifera*)	0	4	1	Several lady beetles. 1	*Aschersonia aleyrodis* 3 *Aschersonia flavo-citrina* 4 *Ægerita webberi* 4 *Microcera* (Fusarium) *sp.* 4 *Verticillium heterocladum* 3	Same as preceding.
Woolly white fly *Aleurothrixus howardi* (*Aleyrodes howardi*)	0	4	4	*Eretmocerus haldemani.* 4 Several lady beetles. 1	*Cladosporium sp.* 3 *Aschersonia aleyrodis* 3 *Ægerita webberi* 3	Same as preceding.
Bay or waxy white fly *Paraleyrodes perseæ*	0	2				Same as preceding.
Black scale *Saissetia oleæ*	4	1	1	*Scutellista cyanea* 4 *Tomocera californica* 3 *Rhizobius ventralis* 3 *Orcus chalybeus* 3 and other lady beetles.	*Isaria* sp. (California) 2	Fumigation hydrocyanic acid gas or spraying.
Purple scale *Lepidosaphes beckii*	4	4	4	*Aspidiotiphagus citrinus* 3 *Rhizobius lophanthæ* 3 *Scymnus marginicollis* 2 *Chilocorus bivulnerus* 2 and other lady beetles.	*Sphærostilbe coccophila* 4 *Microcera fujikuroi* 3 *Microcera* (Fusarium) *sp.* 2 *Ophionectria coccicola* 4 *Myriangium duriæi* 4 *Verticillium heterocladum* 3 (Florida) *Cephalosporium lecanii* (Cuba) 3	Spraying with oil sprays and fungi (Florida). Fumigation and spraying (California).
Long scale *Lepidosaphes gloveri*	1	3	3	Same as preceding.	Most of same fungi as on *Lepidosaphes beckii.*	Same as for *Lepidosaphes beckii.*
Red scale of California *Chrysomphalus aurantii*	4	1	1?	*Aphelinus diaspidis* 3 *Rhizobius lopanthæ* 2		Fumigation or spraying.

A TABLE COMPARING CITRUS INSECT PESTS OF CALIFORNIA, FLORIDA AND CUBA†—Continued.

4 Important. 3 Important only at times or in few localities. 2 Not important. 1 Trace of it reported. 0 Not known to occur.

Common and scientific name	Occurrence			Insect parasites	Fungous parasites	Treatment indicated
	California	Florida	Cuba			
Yellow scale *Chrysomphalus aurantii*, var. *citrinus*	4	0	0	*Aphelinus diaspidis* 3 *Rhizobius lophanthæ* 2 *Aspidiotiphagus citrinus* 3		Fumigation or spraying.
Red scale of Florida *Chrysomphalus aonidum*	0*	3	3		*Microcera fujikuroi* 4 *Microcera* (Fusarium) *sp.* 2	Spraying and fungous parasites.
Greedy scale *Hemiberlesia camelliæ* (*Aspidiotus rapax*)	3			*Aphelinus sps.* 3		Fumigation or spraying.
Oleander scale *Aspidiotus hederæ*	2	2		*Aphelinus sps.* 3 *Aspidiotiphagus citrinus* 2		Fumigation or spraying.
Chaff scale *Parlatoria pergandei*	0	3	3		*Sphærostilbe coccophila* 4	Spraying and fungous parasites.
White scale *Chionaspis citri*	1	3	4		*Sphærostilbe coccophila* 3 *Myriangium duriæi* 3	Spraying and fungous parasites.
Hemisphærical scale *Saissetia hemisphærica*	1	2	2	*Coccophagus lecanii* 3 *Comys fusca* 3 *Scutellista cyanea* 2	*Cephalosporium lecanii* 4 *Empusa sp.* 3	Spraying and parasites.
Citricola scale *Coccus citricola*	4	0	0	*Coccophagus lecanii* 2 *Coccophagus flavo-scutellum* 2 *Coccophagus lunulatus* 2 *Aphycus flavus* 2		Fumigation and spraying.
Soft brown or turtle back scale of Florida *Coccus hesperidum*	3	2	2	*Coccophagus lecanii* 4 *Aphycus flavus* 4 *Encrytus flavus* 4 *Coccophagus lunulatus* 3		Spraying and parasites.
Turtle back scale of Cuba *Lecanium* sp.	0	0	4	*Thalassa flaviceps*	*Cephalosporium lecanii* 4 *Empusa sp.* 3	Spraying and parasites.
Florida wax scale *Ceroplastes floridensis*	1*	3	2		*Aschersonia turbinata* 4	Spraying rarely necessary.

Barnacle scale *Ceroplastes cirripediformis*	1*	1			Spraying rarely necessary.
Cottony cushion scale *Icerya purchasi*	3	3	0?	*Novius cardinalis* 4 *Cryptochætum iceryæ* 4 *Chilocorus bivulnerus* 2	Usually kept in check by insect parasites.
Citrus mealy bug *Pseudococcus citri*	4	3	3	*Cryptolæmus montrouzieri* 3 *Hemerobius* sp. 3 *Syrphus sp.* 3	Fumigation or spraying, and parasites.
Baker's mealy bug *Pseudococcus bakeri*	3	0	0		Fumigation and spraying.
Orange tortrix *Tortrix citrana*	3	3		Braconid sp.	
Fuller's rose beetle *Aramigus fulleri*	3	0*			Cotton bands about trees.
Orange dogs *Papilio cresphontes* *Papilio andræmon*	0 0	3	3 3	Ichneumons	Picking off larvæ.
Green bug *Diabrotica soror*	3	0			
Cotton stainer *Dysdercus suturellus*		3			
Leaf-footed plant-bug *Septoglossus phyllopsus*		3			
Red spider or purple mite *Tetranychus mytilaspidis*	4	4	4	*Conwentzia hageni* 3 *Oligota oviformis* 3 *Stethorus picipes* 3 *Scolothrips sexmaculatus* 2 *Arthrocnodax occidentalis* 2 *Hemerobius sps.* 3 *Chrysopa sps.* 3	Spraying sulfur or lime sulfur or soda sulfur solution.
Six-spotted mite *Tetranychus sexmaculatus*	3	4	4	Same as preceding.	Same as preceding.
Orange rust mite Lemon silver mite *Eriophyes oleivorus*	2	4	4	Syrphus flies 2	Sulfur, lime sulfur or soda sulfur solutions.
Citrus thrip *Euthrips citri*	4	0	0		

A TABLE COMPARING CITRUS INSECT PESTS OF CALIFORNIA, FLORIDA AND CUBA†—Continued.

4 Important. 3 Important only at times or in few localities. 2 Not important. 1 Trace of it reported. 0 Not known to occur.

Common and scientific name	Occurrence			Insect parasites	Fungous parasites	Treatment indicated
	California	Florida	Cuba			
Euthrips bispinosus (*Euthrips tritici* in part)		3				Lime sulfur and tobacco extract sprays.
Heliothrips hæmorrhoidalis	3	2*	4	*Coccinella abdominalis* 3		
Plant lice *Aphis sps.*	2	2	2	*Braconid sps.* 4 *Chilocorus bivulnerus* 2		
Leaf-cutting ant Bibijagua (Cuba) *Atta insularis*	0	3 Southern Florida	4			Carbon bisulphid, sulphur fumes, chloride of lime, etc.
Fire ant *Solenopsis geminata*		2*	4			
Blue-green beetle *Pachnæus litus* and *Pachnæus azurescens*	0	0	4	Ants ?		
Pachnæus opalus		2				
Prickly ash bug *Trirhabda breircollis*		2				
Green bug *Nezarra viridula*		3				
Galerica erosa		2				

*Present in greenhouses only or on plants other than citrus.

†Much help in compiling this table was obtained from J. R. Watson of the Fla. Exp. Sta. and H. J. Quayle of the Cal. Citrus Exp. Sta.

A TABLE COMPARING THE CITRUS DISEASES OF CALIFORNIA, FLORIDA AND CUBA.

Common names	Causal agents	Parts affected	Occurrence			Treatment in brief
			California	Florida	Cuba	
Pythiacystis gummosis or brown rot gummosis	*Pythiacystis citrophthora*	Bark on trunk	Serious on heavy soil	Found present in one locality with Mal di gomma	Common on heavy soils	Digging away earth and cutting away diseased bark and applying fungicide
Botrytis gummosis or grey fungus gummosis	*Botrytis cinerea*	Bark on trunk and sometimes on limbs	In moister coast regions only on lemon trees	Not found	Not found	Cutting away diseased bark and applying fungicide
Mal di gomma or foot rot		Bark at crown roots and trunk of tree	Present to some extent	Serious on old seedling sweet orange trees	About as in Florida	Digging away earth and cutting away diseased bark and applying fungicide
Psorosis California scaly bark	Not known	Bark on trunk and larger limbs	Common on orange trees	Common, but not so prevalent as in California	Small amount seen	Scraping away diseased bark and applying fungicide or eliminating diseased limbs
Nail-head rust, Florida scaly bark		All parts, fruits, limbs and rarely leaves	Not found	Serious only to oranges in one or two counties	Not found	Pruning and spraying
Diplodia gumming	*Diplodia natalensis*	Twigs and limbs	Not found	Widely distributed. At times troublesome, especially to grapefruit	Widely distributed and probably more troublesome than in Florida	Pruning out
Oak root fungus	*Armillaria mellea*	Roots	In local spots in orchards in few sections	Not found	Not found	Isolation by trenches. Elimination from soil by carbon bisulphide
Citrus canker	*Pseudomonas citri*	Fruit, leaves and twigs	Not found	Serious menace to grapefruit in two counties	Not found	Eradication by burning up trees affected

A TABLE COMPARING THE CITRUS DISEASES OF CALIFORNIA, FLORIDA AND CUBA—Continued.

Common names	Causal agents	Parts affected	Occurrence			Treatment in brief
			California	Florida	Cuba	
Melanose	*Phomopsis citri*	Fruits, leaves and twigs	Not found	Common and injurious to fruits and leaves	Not found	Pruning out dead wood and spraying
Scab or Verrucosis	*Cladosporium citri*	Fruits, leaves and twigs	Not found	Common and injurious to grapefruit, lemon and sour orange	More injurious to grapefruit than in Florida	Spraying with fungicides
Wither-tip of limes	*Glœosporium Limetticolum*	Tender twigs, leaves and fruit	Not found	Injurious to lime trees and fruit in southern Florida	Prevalent	
Wither-tip of other citrus trees	*Colletotrichum glœosporioides*	Limbs and leaves	Not so serious as in Florida	Widely distributed and serious, causing much injury	Not so much seen as in Florida	Pruning out
Anthracnose or wither-tip spotting	*Colletotrichum glœosporioides*	Fruits	Occurs frequently on mature fruit	Troublesome during some seasons. More common than in California	Occurs. Seriousness not known	Pruning out and spraying with fungicides
Wither-tip staining and tear streaking	*Colletotrichum glœosporioides*	Fruits	Frequently seen, especially in coast regions in damp years	Very common and prevalent	About same as in Florida	Pruning out and spraying with fungicides
Exanthema or die-back	Causal conditions thought to be wrong conditions of soil or fertilization	Fruit, leaves and twigs	Occurs occasionally but less frequently than in Florida	A very common trouble causing much injury	Only a trace seen in Isle of Pines	Avoid causal conditions
Mottled leaf (California) or Frenching (Florida)	(?) *Tylenchulus semipenetrans* (nematode worm) in part (?)	Leaves, fruits and roots	Serious and common, especially on lighter soils	Not so common nor so serious as in California	About same as in Florida	
Chlorosis or yellowing of leaves over entire surface		Leaves especially	Occurs in few places	Common in few sections	About as in Florida	
Blight	Not known	Entire tree	Not found	Destructive in places on light hammock soils	Occurs occasionally	Digging out trees and burning

Stem-end rot	*Phomopsis citri*	Fruit	Not found	Common and prevalent in some seasons	Not found	Pruning out dead twigs and eliminating scale insects
Diplodia rot	*Diplodia natalensis*	Fruit	Not found	Occurs mostly on weak fruits	More prevalent than in Florida	
Black rot Navel end rot	*Alternaria citri*	Fruit	Occurs on Navel oranges especially	Rarely seen	Rarely seen	
Blue mold decay	*Penicillium italicum*	Fruit	Common	Common	Common	Careful handling to avoid injuries
Green mold decay	*Penicillium digitatum*	Fruit	Common	Common	Common	Careful handling to avoid injuries
Gray mold	*Botrytis cinerea*	Lemon fruits	On weak lemons	Not found	Not found	
Brown rot	*Pythiacystis citrophthora*	Fruit	Serious at times. especially on lemons	Not certainly known on fruit	Reported by growers on lemons	Straw under trees. Spraying and use of $CuSo_4$ in wash water
Cottony rot	*Sclerotinia libertiana*	Fruit	Sometimes serious on lemon fruits	Not found	Not found	
Black pit	*Pseudomonas citriputeale*	Fruit	Minor spot usually on injured fruits	Not found	Not found	
Brown spot	Not known	Fruit	Serious some years, especially on Navels	Not found	Not found	
Green spot	Oil liberated from rind in picking and handling	Fruit	Serious some years on lemons	Not found	Not found	
Peteca	Not known	Fruit	Serious some years on lemons	Not found	Not found	
Red blotch	Not known	Fruit	At times a serious trouble in packing houses	Not reported	Not reported	
Trunk rot	*Schizophyllum commune*	Wood of trunk and large limbs	Serious on poorly pruned trees.	Not reported	Not reported	Proper pruning and care of wounds
Twig blight	*Sclerotinia libertiana*	Twigs	Attacks lemon twigs, especially some seasons	Not found	Not found	Pruning out

A TABLE COMPARING THE CITRUS DISEASES OF CALIFORNIA, FLORIDA AND CUBA—Continued.

Common names	Causal agents	Parts affected	Occurrence			Treatment in brief
			California	Florida	Cuba	
Citrus knot	*Sphæropsis tumefaciens*	Twigs and limbs	Not found	Not found	Few cases found	Pruning out
Galls	(?) *Bacillus tumefaciens*	Twigs and limbs	Occurs occasionally	Not found	Not found	Pruning out
Damping off	*Rhizoctonia sp.*	Stems of small seed bed and nursery stock	Common and troublesome	Common and troublesome	Common and troublesome	Good drainage and not too much water
Fly-speck fungus	*Leptothyrium pomi*	Fruit	Not found	Common	Not found	Spraying if necessary
Alga spot or wart-like spot	*Mycoidea parasitica*	Leaves	Not found	Not found	Sometimes injurious	Spraying with fungicide.
Lichen spot or silver spot	Lichens, various species	Leaves	Not found	Occurs occasionally	Sometimes troublesome	Spraying with fungicide
Lichens	Various kinds	Surface of trunk and large limbs	Occurs occasionally in coast regions	Common everywhere	Common	Spraying with fungicide when necessary
Yellow spotting	Not known	Leaves	Not found	Occurs occasionally	Not found	
Black greasy spot (Black Melanose)	Not known	Leaves	Not found	Common on citrus leaves especially in southern Florida	Prevalent everywhere and more pronounced than in Florida	
Gum spots or leaf spot		Leaves	Occurs occasionally	Not found	Not found	
Dodder or gold thread or love vine	*Cuscuta sp.*	Young seed-bed trees.	Occasionally does harm	Not found	Not found	Picking off when first starting

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